INSTRUCTION MANUAL

Type 1921 Real-Time Analyzer

A

GENERAL RADIO

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WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

Type 1921 Real-Time Analyzer

A

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West Concord, Massachusetts, U.S.A. 01781
Form 1921-0100-A
December, 1969
ID 0100

Condensed Operating Instructions

The following sequence of steps is recommended for operation of the 1921 Real-Time Analyzer:

Calibration With Known Signal.

a. Set the attenuator of the channel corresponding to the test frequency to between +15 and +25 dB, depending on sensitivity desired. Nominal "full scale" sensitivity is about 0.2 V at +15 dB and 0.06 V at +25 dB. Gain can be adjusted from +6 to −12 dB with these nominal values.

b. Apply a calibration signal of known level and frequency to either INPUT connector on the 1925 Multifilter.

c. Switch system line POWER on (front-panel switch on 1925).

d. Set LOWEST BAND NUMBER and HIGHEST BAND NUMBER controls on 1926 to band that contains frequency of calibration signal.

e. Observe PEAK MONITOR on front panel of the 1925 Multifilter. If pointer is in red region, reduce level by adjusting CAL control on 1925.

f. Set 1926 controls to 1 SECOND INTEGRATION TIME, MULTIPLE MODE, XY PLOT. Push START and PANEL DISPLAY buttons.

g. Observe BAND LEVEL dB Nixie-tube indicators. (Slow down display by adjusting DISPLAY RATE control, if necessary.)

h. Adjust MAXIMUM BAND LEVEL dB thumbwheels until display reads correct level for that calibration signal. (Use CAL control on 1925 for fine adjustment, if needed.) All subsequent data will now read directly in the appropriate decibel values for the reference of the calibration signal (e.g., 0.0002 μbar, 1 $\mu N/m^2$, etc.).

NOTE

An "8" or "9" in the most-significant digit of the display indicates an overload condition in the ***detector***. To alleviate the overload condition, lower the CAL control on the 1925 and readjust the MAXIMUM BAND LEVEL dB control on the 1926 to restore the appropriate reference-level reading.

If the calibration signal is varying too rapidly to obtain a reference setting, choose a longer INTEGRATION TIME.

If no calibration signal is available, try to obtain on-scale readings from data to be analyzed, either by finding the maximum level anticipated (and making this "full scale") or by making lowest level appear at lowest part of scale.

Calibration of Output-Display Devices.

After performing the above procedure:

a. Remove the signal from input.

b. Set LOWEST BAND NUMBER control on 1926 to the ***second*** band ***below*** lowest standard band number on the 1925 panel. Set HIGHEST BAND NUMBER control to next band above LOWEST BAND NUMBER setting (refer to paragraph 3.3.2). The lower band is the "full scale" reference, corresponds to the setting of the MAXIMUM BAND LEVEL dB control, and covers the 60-dB display range. The higher band is the "zero" reference for the output display.

c. The resulting signals at the analog and digital outputs can then be used to set full-scale and zero (60 dB below full scale) points on X-Y plotters, oscilloscopes, digital printers, etc. (The bands can be selected one at a time, if desired.)

Measurement Procedure.

a. Connect a signal line to either of two INPUT connectors on rear of 1925 Multifilter.

b. Switch POWER ON.

c. Set the LOWEST BAND NUMBER and HIGHEST BAND NUMBER controls to display the frequency range of interest.

NOTE

The 1921 will always ***measure and store*** the ***entire*** spectrum, regardless of these settings; therefore, the settings can be changed at any time, or expanded after the measurement, if the mode is SINGLE-HOLD.

d. Observe the PEAK MONITOR on front panel of 1925. If the pointer is in the red region, reduce gain with the CAL control.

e. Set the front-panel controls on the 1926 to select:

1. INTEGRATION TIME (select one of the nine buttons).

2. MEASUREMENT MODE (refer to Table 1-4, for details).

(a.) SINGLE for one measurement and one output cycle.

(b.) SINGLE-HOLD for one measurement and *repeated* output cycles.

(c.) MULTIPLE for repeated measure/output cycles.

3. OUTPUT DISPLAY Devices.

Select the appropriate OUTPUT DISPLAY button for the output device used. If more than one display device is used, the output rate should be set to accommodate the slowest device.

The 1921-P1 Storage Display Unit is always activated in the STORE-NO-ERASE mode, regardless of which display button is depressed. (Refer to Table 1-4.)

4. REMOTE and MANUAL Controls.

Refer to paragraph 3-4 for information on use of REMOTE and MANUAL positions.

f. Push START button. Measurement and display sequence(s) will automatically cycle per the preset conditions above. In MULTIPLE and SINGLE-HOLD modes, cycling will continue until the STOP, START, or PAUSE button is pushed.

g. Note the BAND LEVEL indication on the 1926 and the output-display device.

Use of PAUSE button.

The PAUSE control should be used ***only to halt the output cycle*** of the 1921. When the 1921 is measuring the input signal, the INTEGRATING indicator is illuminated. When the 1921 is ***displaying*** information obtained during the measurement, the INTEGRATING indicator is darkened, and only the pilot spot above it is illuminated. The PAUSE button, when depressed, halts the 1921 (to allow output devices to be adjusted, etc.) and latches in that position. When it is pushed again, it releases, and the display resumes at the point in its cycle at which the PAUSE button was pushed.

Use of the STOP button results in the need to push the START button to resume operation. This, then, destroys the previously measured data and makes an entirely new measurement.

Detector Overload.

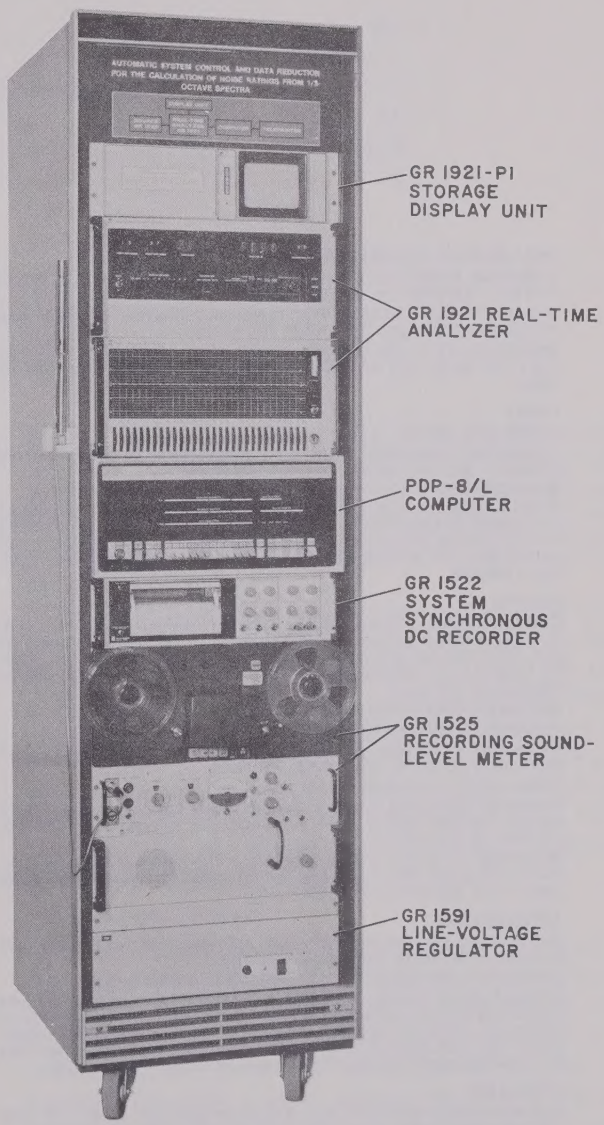
If the measured signal level has exceeded the capacity of the 1926 Multichannel RMS Detector in any of its bands, that band-level (or levels) is displayed as follows:

1. Digital indicators and digital data read "8" or "9" in the most significant digit (i.e., 8XX.XX or 9XX.XX).

2. Analog data are made to jitter quite noticeably (i.e., scope trace brightens, X-Y plot jitters).

All other band-level data are still valid, but the overloaded channel bandlevels should be disregarded.

To correct the overload condition, reduce the gain with the CAL control on the 1925.



Typical computer-controlled system built around the 1921 Real-Time Analyzer.

Specifications

OPERATIONAL CHARACTERISTICS

Frequency Range: 30 1/3-octave filter channels from 3.15 Hz to 80 kHz in standard models (see table).

Dynamic Range: 70 dB; 60-dB range is displayed, thus allowing a crest-factor margin of 10 dB at full scale.

Sensitivity: 0.1 V rms nominal for full scale. Can be increased to 5 mV full scale with GR 1560-P40 Preamplifier (power supplied by 1921).

INPUT

Impedance: 100 kΩ.

Voltage: AC component, ± 17 V pk max referred to dc component of input. DC component, ± 35 V max.

Gain Adjustment: 18 dB continuous, common to all channels.

Peak Monitor: A peak detector senses levels at two circuit points and drives a panel meter calibrated in dB referred to overload level. A signal proportional to meter deviation is available at an output jack for driving a dc recorder; 1 mA corresponds to full-scale reading.

FILTERS

Characteristics: One-third-octave effective (noise) bandwidths. Filters are six-pole Butterworth designs and meet current American and International standards: 1/3-octave filters conform to ANSI S1.11-1966 Class III (high attenuation) and IEC Recommendation Publication 225-1966.

Accuracy of Center Frequency: ±2%.

Passband Ripple: 0.5 dB max pk-pk.

Uniformity of Levels (at center frequencies, attenuator at +25 dB): ±0.25 dB at 25°C; ±0.5 dB, 0 to 50°C.

Noise: <15 μV equivalent input noise.

Harmonic Distortion (at band centers): For bands centered at 25 Hz and above, <0.1% at 1-V output. For bands below 25 Hz, <0.25% at 1-V output.

Weighting: A, B, and C characteristics of weighted channels conform to current American and International standards including ANSI S1.4, IEC R123, and IEC R179.

ATTENUATORS

Range: Gain in each filter channel adjustable in 1-dB steps over a range of 50 dB by front-panel controls.

Accuracy: ±0.25 dB relative to indicated +25-dB setting.

Readout: Panel display indicates attenuation in each channel and represents the transmission between input and summed output of multifilter. Display has standard 50-dB-per-decade scale factor; 10 dB per inch vertical, 5 inches per decade horizontal. Key lock on panel prevents accidental changes in attenuator setting.

DETECTOR

Characteristics: RMS with true (linear) integration. Choice of nine integration periods: ⅛, ¼, ½, 1, 2, 4, 8, 16 and 32 seconds.

Linearity: ±0.5 dB deviation from best straight-line fit over the top 50 dB of display range for any channel; ±1 dB over entire 60-dB range.

Sampling: Time between samples depends upon integration period selected. Sampling rate is swept over a range of about 1.8:1 during integration period to minimize coherence effects. 1024 samples are taken during integration periods of 1 to 32 seconds. Below 1-second integration period, the quantity of samples is reduced, in proportion to the integration period, to a minimum of 128.

Crest-Factor Capacity: 10 dB at full scale, increasing below full scale. Repeatability is better than 1 dB (one-σ limit) for tone burst with duty factor of 1/100 (equivalent to crest factor of approximately 23 dB) when rms levels are less than 13 dB below full scale.

Memory Duration: Unlimited while power is on.

OUTPUTS

Analog Output: Detected level output (Y axis) is linear in dB for a range in voltage of 0 to +1V ±10%, corresponding to 0 to 60 dB. Channel-number (X axis) data are linear with 0 to 1-V nominal output swing. Adjustable to 1-V swing, corresponding to quantity of output channels ranging from 10 to 45. Channels are designated by ANSI Standard Band Numbers. Overload in any channel is indicated by a "jitter" superimposed on the "level" voltage for that channel.

Digital Output: Levels in dB from 0 to 159 dB (in 0.25-dB steps) are represented by five BCD digits. Band number is reported by two BCD digits. Logic is standard 5-V TTL (positive true) for both level and band number. Overload in any channel is indicated by presence of an 8 or 9 as the most significant digit in the level indication corresponding to the channel number.

Display: Five neon readout tubes display band level in dB. Two neon readout tubes display standard band numbers (per ANSI S1.6 and S1.11).

Calibration: Full-scale and zero-level self calibration provided in two auxiliary channels. Front-panel controls allow a calibration factor to be added to digital output; full-scale indication is adjustable from 60 to 159 dB in 1 dB steps.

GENERAL

Accessories: Synchronizing and control signals provided for CRT display, automatic recorders, scanners, data printers, and computers. Interfaces specifically designed for GR 1522 DC Recorder, GR 1921-P1 Storage Display Unit, Houston Instruments 6400-024-series plotters, and Mohawk Data Sciences model 800 High-Speed Printer. 1925-9670 Transmission Record Sheets, thin mylar sheets, same size and with same scale as 1925 display window; used to record position of dots in window with grease pencil or other marker; attaches to window with self-contained adhesive strip.

Programmability: All panel-control functions except output display rate are programmable by contact closures or solid-state switches to ground.

Power Required: 100 to 125 or 200 to 250 V, 50 to 60 Hz, 135 W.

Mounting: Rack or bench (mounted in single metal cabinet).

Dimensions (width x height x depth): Bench, 19½ × 19 × 20 in. (495 × 485 × 510 mm); rack, 19 × 17½ × 16 in. (485 × 445 × 410 mm).

Weight: Bench, 95 lb (44 kg) net, 190 lb (87 kg) shipping; rack, 80 lb (37 kg) net, 120 lb (55 kg) shipping.

— See **GR Experimenter** for May-June 1969.

NOTE

Effective October 6, 1969, USASI is changed to ANSI, American National Standards Institute and "USA Standards" become "American National Standards." The reference numbers remain unchanged.

Introduction—Section 1

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1.1 PURPOSE.

The Type 1921 Real-Time Analyzer is a new generation analyzer. It performs real-time one-third-octave spectrum analysis in the frequency range from 3.15 Hz to 80 kHz, employing a digital-detection scheme to achieve performance unattainable with analog techniques.

1.2 DESCRIPTION.

1.2.1 Standard Versions.

The major components of the Analyzer are the Type 1925 Multifilter and the Type 1926 Multichannel RMS Detector. For complete details, the reader should refer to the instruction manuals for the individual instruments.

Filters in the 1925 conform to American and International standards. The Multifilter includes a calibrated attenuator in each filter channel to permit pre-whitening or weighting. The attenuators can also be used to correct transducer or tape-recorder errors or to extend the dynamic range of the analyzer. The attenuation is controlled by individual thumbwheels and indicated on a panel display. The Multifilter also includes FLAT, A-, B- and C-weighting networks.

The Type 1926 Multichannel RMS Detector processes the signal from the Multifilter digitally. The outputs of the filters are sampled, the sample data converted to digital binary form, and the binary numbers fed to a digital processor that computes root-mean-square level. There are several advantages in this method of RMS detection as compared with analog methods. A very wide dynamic range can be realized while an accurate rms characteristic is maintained.

The averaging method is true (linear) integration, with a choice of nine integration periods from 1/8 to 32 seconds. A true integration scheme not only gives answers faster than the running-average circuits found in analog devices but also makes it possible to determine exactly what events in time have affected the answer. The computed band levels are stored in a digital memory, to be accessed at a rate limited only by the output recording or storage device. The analyzer simultaneously produces both digital (1-2-4-8 code) and analog outputs.

The 1921 is available in eight standard 30-channel versions (refer to Table 1-1), including four versions with adjustable calibrated attenuators and four without, and either bench or rack mounted. The four standard three-decade frequency ranges include bands extending down to 3.15 Hz and up to 80 kHz. A-, B-, and C-weighted sound level, as well as a flat-frequency-response channel, are built into all versions. The analyzer's filter section (Type 1925 Multifilter) can also function as a spectrum synthesizer, equalizer, or shaper.

1.2.2 Custom Versions.

The 1921 Real-Time Analyzer has also been designed to allow great flexibility in the number and bandwidths of filters and input and output devices. Custom versions with up to 45 channels, octave bands, mixtures of octave and one-third-octave bands, and special bandwidths can be supplied. Complete custom systems from transducer to final data storage (even including a computer for rapid storing of data, determining ratings, making comparisons, etc.) are also available.

1.3 CONTROLS, INDICATORS AND CONNECTORS.

The controls, indicators and connectors on the front and rear panels of the Analyzer are listed in Tables 1-2 through 1-6.

1.4 ACCESSORIES SUPPLIED.

The accessories supplied with the 1921 Real-Time Analyzer are listed in Table 1-7.

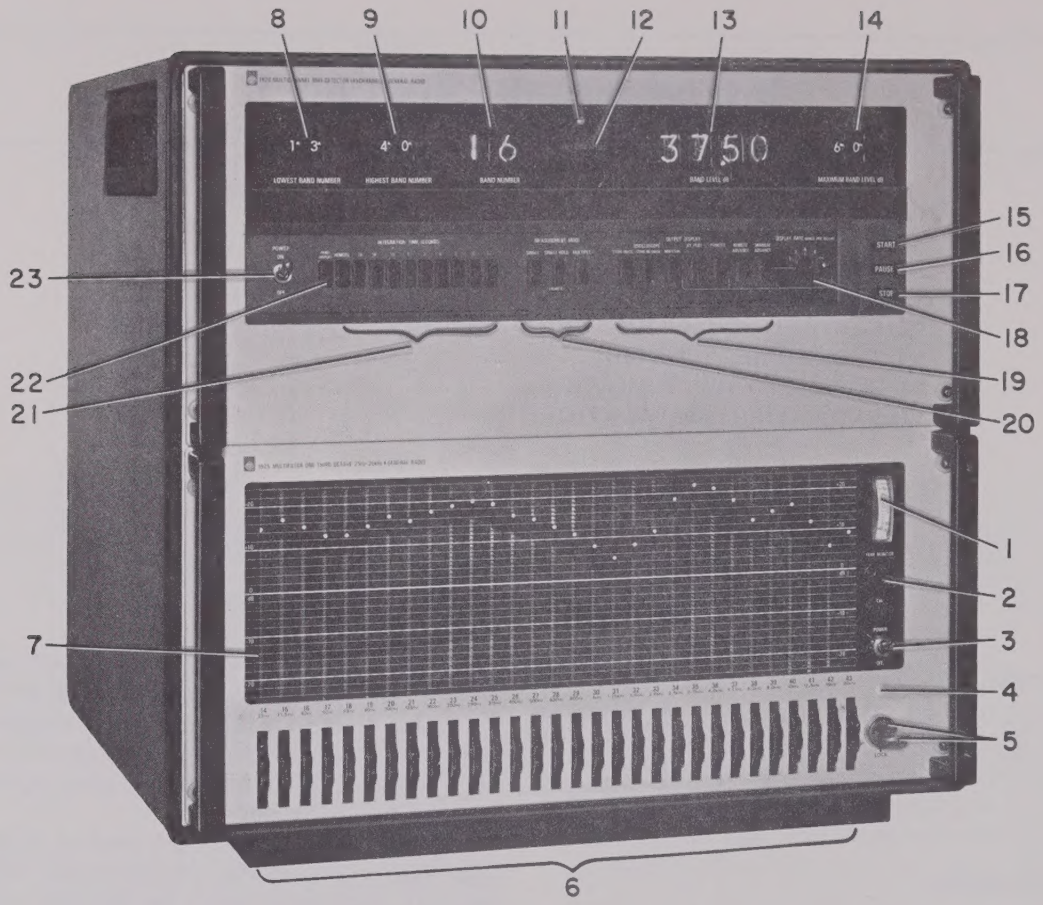


Figure 1-1. Front-panel controls and indicators on the 1921 Real-Time Analyzer.

Table 1-1
BASIC VERSIONS OF THE ANALYZER

Description	*GR Catalog Number*			
	With Attenuator		*Without Attenuator*	
	Bench	*Rack*	*Bench*	*Rack*
1921 Real-Time Analyzer One-Third-Octave Bands				
25 Hz to 20 kHz	1921-9700	1921-9701	1921-9708	1921-9709
12.5 Hz to 10 kHz	1921-9702	1921-9703	1921-9710	1921-9711
3.15 Hz to 2.5 kHz	1921-9704	1921-9705	1921-9712	1921-9713
100 Hz to 80 kHz	1921-9706	1921-9707	1921-9714	1921-9715

Table 1-2
FRONT-PANEL CONTROLS AND INDICATORS – TYPE 1925

Fig 1-1 Ref.	*Name*	*Type*	*Function*
1	PEAK MONITOR [1]	Panel meter	Indicates overload. Calibrated in dB referred to overload level. Driving circuitry normally selects higher of two peaks measured at the input to the Multifilter when it is used in an analyzer system.
2	CAL	Thumbset control	Adjusts over-all gain of instrument from approx. +6 to −12 dB.
3	POWER	Toggle switch	Turns instrument on and OFF.
4	——	Pilot light	Indicates when instrument is energized.
5	LOCK	Lock and key	Locks all attenuator thumbwheels at once, in any position, to prevent accidental changes.
6	——	Thirty thumb-wheels (Omitted on 1921-9708 through 1921-9715)	Control calibrated attenuators in 1-dB steps. Each wheel corresponds to a filter channel. Attenuation indicated by display dot directly above each wheel.
7	——	Attenuation display	Indicates relative level of attenuation in individual filter channels and nominal gain in each. Gain calibration is absolute when CAL thumbset control is set so that instrument gain is 0 dB through any filter channel, with its attenuator set at 0 dB. The attenuation display has a standard scale factor of 50 dB/decade. The vertical scale is calibrated with 10 dB/in. and the horizontal scale with 5 in./decade.

[1] Refer to paragraph 2.9.

Table 1-3
FRONT-PANEL CONTROLS AND INDICATORS ON THE 1926 RMS DETECTOR

Fig. 1-1 Ref.	*Name*	*Type*	*Function*
8	LOWEST BAND NUMBER	Thumbwheel switches (2)	Select the number of the first band to be displayed during the output mode. Normally set to values between 0 and 49, but is sometimes set to 62 or 63 for self check.
9	HIGHEST BAND NUMBER	Thumbwheel switches (2)	Select the number of the last band to be displayed during the output mode. Adjustable from 0 to 49.
10	BAND NUMBER	Nixie tubes	Indicates the number of the standard band being displayed.
11	Pilot Light	Illuminated spot	Indicates when the instrument is energized (line power is on).
12	INTEGRATING	Illuminated sign	Indicates that the instrument is in the measuring mode.
13	BAND LEVEL dB	Nixie tubes	Indicates the level, in dB, of the standard band being displayed.
14	MAXIMUM BAND LEVEL dB	Thumbwheel switches (2)	Select the level, in dB, that will be displayed for a 1-V, rms, input (to 1926) signal. Can be adjusted from 60 to 159 in 1-dB steps.
15	START	Pushbutton	Actuates the measurement mode.
16	PAUSE	Locking pushbutton	Interrupts the instrument operation at any time. When released, the instrument operation resumes at the point at which it was interrupted when PAUSE was actuated (provided no other control settings have been changed during PAUSE). Do not use PAUSE when the INTEGRATING light is on. It is intended for use during the OUTPUT phase.
17	STOP	Pushbutton	Stops the operation of the instrument. The START button must be used to resume operation after the STOP button has been depressed.

Table 1-4

CONCEALED FRONT-PANEL CONTROLS (1926)

Fig. 1-1 Ref.	*Name*	*Type*	*Function*
18	DISPLAY RATE — BANDS PER SECOND	8-position rotary switch	Selects the number of bands per second to be displayed when either the XY PLOT or PRINTER mode is selected. Reset time (which occurs just before a new display) is 1 ms when PRINTER is selected or 1/2 s, when XY PLOT is selected.
19	OUTPUT DISPLAY	Seven locking pushbuttons	
	OSCILLOSCOPE		The following three buttons are for oscilloscope display and result in a display rate of 1 ms per channel.
	STORE-ERASE		In this mode, oscilloscope storage is enabled and erase takes place.
	STORE-NO ERASE		In this mode, oscilloscope storage is enabled and no erase takes place.
	NON-STORE		This mode is for standard oscilloscope use, or with a storage scope and no use of the storage feature.
	XY PLOT		X and Y outputs are enabled plus storage (for oscilloscope) pen-lift command and print command. Display rate is variable by means of DISPLAY RATE control. Reset or retrace time is 1/2 s and takes place just before new data is ready.
	PRINTER		Print command and store (for oscilloscope) are enabled. Display rate is variable by means of the DISPLAY RATE control and reset or retrace time is 1 ms. When both a printer and a plotter are used simultaneously with the analyzer, and when the 1921 controls the output rate, the XY PLOT mode can be selected.
	REMOTE ADVANCE		Used when an external device, such as a printer or computer, is to control the output rate. In this mode, all output signals are enabled.
	MANUAL ADVANCE		Used to advance channels manually when the DISPLAY RATE control is set to the position adjacent to the MANUAL button.

Table 1-4 (cont)

CONCEALED FRONT-PANEL CONTROLS (1926)

Fig. 1-1 Ref.	*Name*	*Type*	*Function*
20	MEASUREMENT MODE	Three interlocked pushbuttons	
	SINGLE		SINGLE mode results in one measurement period and one display period each time the START button is depressed.
	SINGLE-HOLD		SINGLE-HOLD mode results in one measurement period and repeated display periods (of the same data) each time the START button is depressed. This button must be depressed for remote selection of the MEASUREMENT MODE.
	MULTIPLE		MULTIPLE mode results in repeated cycles of one measurement period and one display period after being actuated by the START button. The process continues until "told" to stop.
21	INTEGRATION TIME SECONDS	Ten interlocked pushbuttons	Select the duration of the integration period. Selectable in octave steps from 1/8 to 32 seconds. REMOTE button in this group disengages the other 9 buttons, so that INTEGRATION TIME can be selected by remote operation.
22	PANEL DISPLAY	Locking pushbutton	Enables the BAND NUMBER and BAND LEVEL dB Nixie tubes when this button is depressed.
23	POWER	Toggle switch	Turns the instrument on and off.

1.5 ACCESSORY INSTRUMENTS.

1.5.1 General. (see Figure 1-3)

A few of the many ancillary devices that can be used with the 1921 Real-Time Analyzer are noted below, together with a short description of each.

1.5.2 CRT Display, Type 1921-P1.

The Type 1921-P1 Storage Display Unit is a modified version of the Tektronix Type 601 Storage Display Unit. Although any CRT display device having horizontal and vertical deflection sensitivity of about 1 V, full scale, can be used with the 1921, this unit is especially suitable. It provides a 3-inch by 3 7/8-inch XY plot of the 1921 band levels versus band number.

A CRT display is useful for set-up and as a semi-quantitative, very fast analog output device. It is the fastest form of analog output but, of course, it produces no permanent record and it does not have as good resolution as most analog recorders. This accessory is recommended for use with the 1921 no matter what other accessories are chosen.

The 1921-P1 is supplied complete as a standard production unit with suitable interconnecting cable and graticules for use with the 1921.

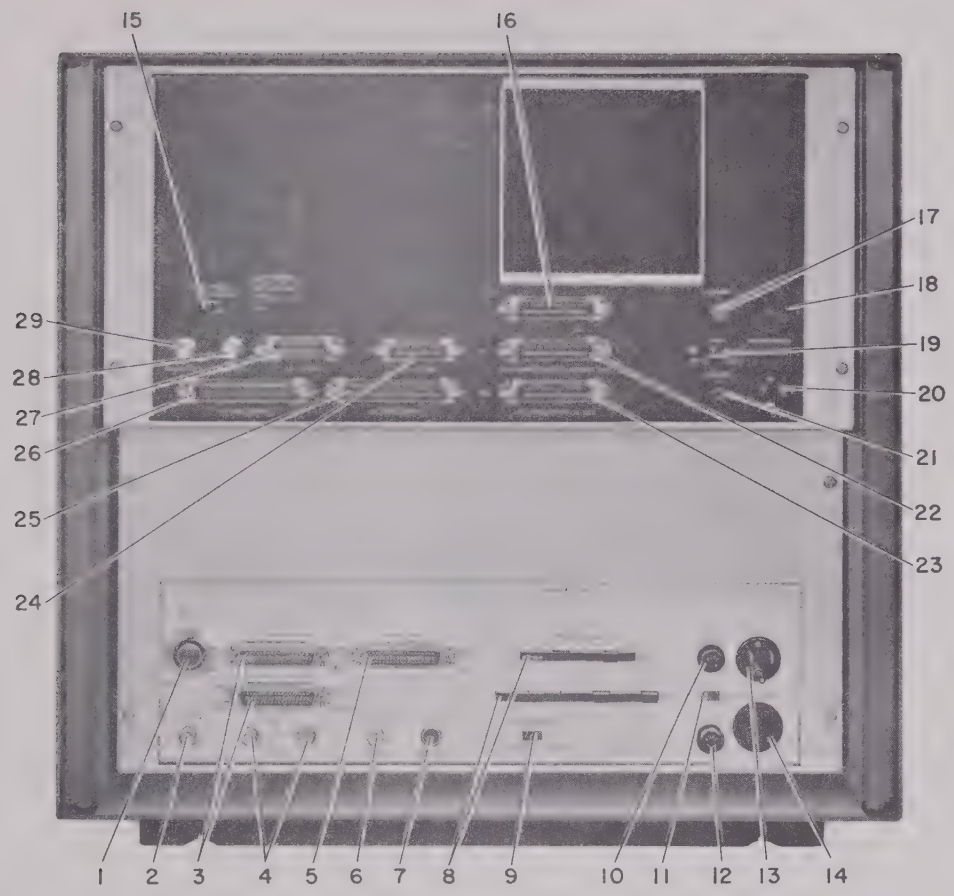


Figure 1-2. Rear-panel controls and connectors on the 1921 Real-Time Analyzer.

Table 1-5

REAR-PANEL CONTROLS AND CONNECTORS ON TYPE 1925

Fig. 1-2 Ref.	*Name*	*Type*	*Function*
1	INPUT 100 kΩ	Cannon XLR-3-31 three-terminal locking microphone socket	Connection for input signal. In parallel with rear-panel BNC connector. Maximum input signal level ±17 V, peak, referred to dc component of input signal. Dc level at this connector must not exceed ±35 V. Power (15 V) to operate 1560-P40 Preamplifier available at terminal #2.
2	INPUT 100 kΩ	BNC coaxial jack	Connection for input signal. In parallel with Cannon XLR socket (above). Same restrictions apply.

Table 1-5 (cont)

REAR-PANEL CONTROLS AND CONNECTORS ON TYPE 1925

Fig. 1-2 Ref.	*Name*	*Type*	*Function*
3	TO 1771 SCANNER CONTROL and TO AUXILIARY 1925 MULTIFILTER	Two, 36-terminal connectors wired in parallel (mate with Amphenol Plug 57-30360)	Connects ten-line drive from 1771 Scanner Control to reed switches in Multifilter chassis. Scanner Control used to address bands when BAND SELECTOR REMOTE (1771) button (8) is depressed. All internal power-supply voltages (including ±10.6 V, ±10.0 V, and +15 V) are also available at these connectors. When more than one Multifilter chassis is used in a system, the 1771 Scanner Control address is connected to the additional chassis using the lower of these connectors (TO AUXILIARY 1925 MULTIFILTER).
4	SCANNED OUTPUT	Two BNC coaxial jacks wired in parallel	The output in the band selected, using either the 1771 Scanner Control or the STANDARD BAND pushbuttons, is available at these terminals. Ouput impedance is approx. 20 Ω. Load impedance should not be less than 3 kΩ for normal operation. Maximum output voltage is ±4.2 V, peak (3 V, rms, sine wave). Lower load impedances reduce maximum allowed output voltage. This output for serial analyzer systems, or when individual channels must be selected either manually or remotely, using the scanner control.
5	CHANNEL OUTPUTS	36-terminal connector (mates with Amphenol plug 57-30360)	All filter outputs are available in parallel at this connector. Also, A-, B-, and C-weighted sound level and a flat (unweighted) channel are available here. This output is for connection to a parallel detector for high-speed (parallel) spectrum analysis. Output impedance from all channels is low (about 20 Ω). Channels can be loaded simultaneously with an impedance of 3 kΩ or greater. Maximum output voltage is ±4.2 V, peak (3 V, rms, sine wave). Lower load impedances reduce maximum allowed output voltage.
6	SUMMED OUTPUT	BNC coaxial jack	Signal at this output is proportional to sum of all filter channels. This output is mainly for spectrum shaping, synthesizing, or equalizing application. Maximum output voltage is ±4.2 V, peak (3 V, rms, sine wave). Output impedance is 600 Ω. Any load can be connected without affecting linear operation of the output circuits.

Table 1-5 (cont)

REAR-PANEL CONTROLS AND CONNECTORS ON TYPE 1925 [1]

Fig 1-2 Ref.	*Name*	*Type*	*Function*
7	PEAK MONITOR OUTPUT	Closed-circuit phone jack (mates with Switchcraft #440 Plug)	Supplies output current proportional to PEAK MONITOR meter indication. Output current is 1 mA, dc, corresponding to a meter indication of 0 dB. Load impedance should not exceed 2 kΩ. This output is intended to drive a dc recorder or alarm system to monitor peak levels in the Multifilter, thereby detecting an overload condition.
8	STANDARD BAND	Set of 17 push-button switches (7 in top row, 10 in bottom row)	Selects the filter to be connected to the SCANNED OUTPUT panel connectors. Also connects scanner circuitry to the 1771 Scanner Control when REMOTE (1771) button is depressed. Band numbers are as specified in USA Standard S1.6-1967.
9	CHASSIS CONNECTION TO CIRCUIT GROUND	Recessed slide switch, with white line indicator (See item 15)	Connects chassis to circuit ground either directly or through a 10-Ω resistance. Switch is normally in DIRECT position. Setting switch to 10-Ω position prevents circuit ground currents from flowing in the chassis when ground-loop problems arise with system installations. The 10-Ω resistance is low enough to provide good cabinet shielding.
10	3/10 AMP	Extraction-post fuse holder	Holds 3/10-A, Slo-Blo fuse, directly in series with high side of line, and is effective for 115-V operation.
11	50-60 Hz (100-125 V) (200-250 V)	Recessed slide switch, with white line indicator	Connects power supply to accept 100- to 125-V or 200- to 250-V line.
12	15/100 AMP	Extraction-post fuse holder	Holds 15/100-A, Slo-Blo fuse, wired between the halves of a split transformer primary winding. Effective for both 115- and 230-V operation.
13	——	3-terminal male connector	Line-power input connection.
14	SWITCHED POWER	3-terminal female connector	Connects to line power through POWER toggle switch on front panel. Supplies line power for equipment when Multifilter is turned on. This source of power is not fused.

[1] OUTPUT PEAK MONITOR slide switch added. Refer to paragraph 2.9.

Table 1-6
REAR–PANEL CONTROLS, CONNECTORS, AND INDICATORS
ON THE 1926

Fig. 1-2 Ref.	*Name*	*Type*	*Function*
15	CHASSIS CONNECTED TO CIRCUIT GROUND DIRECT– THROUGH 10 Ω	Recessed Slide Switch (See item 9)	Connects circuit ground to chassis either directly or through a 10-Ω resistance. Should be set to 10 Ω to prevent circuit ground currents from flowing in the chassis, and the corresponding switch (9) on the 1925 should be set to DIRECT or 10 Ω, depending upon whether or not system grounding problems arise.
16	AJ7	36-terminal connector (mates with Amphenol Plug 57-30360)	Connects to X and Y outputs and commands for STORE and ERASE. Used for inputs to oscilloscopes.
17	1 6/10 AMP	Extraction-post fuse holder	Holds a 1 6/10-A Slo-Blo fuse directly in series with high side of line. Fuse is effective for 115-V operation.
18	SWITCHED POWER	3-terminal female connector	Connects to line power through POWER toggle switch on front panel. Supplies line power for operation of accessory equipment when Detector is turned on. This source of power is not fused.
19	50-60 Hz (100-125 V) (200-250 V)	Recessed slide switch	Connects power supply to accept 100- to 125-V or 200- to 250-V line.
20	———	3-terminal male connector	Line-power input connection
21	8/10 AMP	Extraction-post fuse holder	Holds 8/10-A, Slo-Blo fuse, wired between the halves of a split transformer primary winding. Effective for both 115- and 230-V operation.
22	AJ5 CHANNEL INPUTS (TO AUXILIARY 1925)	36-terminal connector (mates with Amphenol Plug 57-30360)	Connects to the highest 30 (of 45 possible) channel inputs. The first 15 are wired in parallel with the upper 15 of AJ6 CHANNEL INPUTS connector[1]
23	AJ6 CHANNEL INPUTS (TO 1925)	36-terminal connector (mates with Amphenol Plug 57-30360)	Connects to the lower 30 (of 45 possible) channel inputs.

[1]Highest 15 channels are not active in standard 30-channel versions of the detector.

Table 1-6 (cont)
REAR-PANEL CONTROLS, CONNECTORS, AND INDICATORS ON THE 1926

Fig. 1-2 Ref.	*Name*	*Type*	*Function*
24	AJ3 (TO1566)	24-terminal connector (mates with Amphenol Plug 57-30240)	Remote control signals for use with microphone preamplifier.
25	AJ4 DIGITAL OUTPUT	50-terminal connector (mates with Amphenol Plug 57-30500)	All digital outputs available at this socket.
26	AJ2 PANEL CONTROLS	50-terminal connector (mates with Amphenol Plug 57-30500).	Remote control signals for panel controls.
27	AJ1 (TO1522)	24-terminal connector (mates with Amphenol Plug 57-30240)	Supplies control signals and outputs for XY Recorder or 1522 DC Recorder.
28	ANALOG LEVEL Y	BNC coaxial jack	Supplies an analog voltage proportional to band level. Levels correspond to a maximum band level of 60 dB.*
29	ANALOG FREQ X	BNC coaxial jack	Supplies an X-sweep ramp voltage that starts at zero when the output mode begins.*

*Not for use with an oscilloscope.

1.5.3 Chart Recorder, Type 1522 (refer to para. 3.4.1).

The GR 1522 DC Recorder is recommended for use with the 1921. It is a remote-programmable, high-speed, servo-type level recorder.

It operates with a short dwell as each new band level is selected, to produce a neat, rectangular bar graph, with standard scale factor. The chart drive, which provides the capability for remote programming, is produced by a stepper motor (rather than a synchronous motor). Each step moves the paper only 0.0067 in. Maximum and minimum limits that can be set anywhere along the chart are provided. This feature is useful for setting absolute maximum sound limits and provides a control signal that shuts down a device if the sound level is exceeded or if the recorder goes off scale.

The 1522, in conjunction with the 1921 Analyzer, produces a chart recording in about 6 seconds. Eleven standard chart papers are available.

1.5.4 Tape Recorder, Type 1525.

The Type 1525 Data Recorder is tailored specifically for acoustic-noise measurements. This instrument is both a sound-level meter and audio tape recorder. With it one can make on-location measurements and calibrated recordings for unhurried and detailed laboratory analysis later, or make a permanent record of once-only events. The 1525 permits recording with a flat frequency response characteristic, recommended for recording noise. Dual channels, simultaneous playback and recording, two-speed drive, and accessory tape-loop guides add versatility.

The 1525 Recorder produces a maximum output level of about 1 V to drive the analyzer. A calibrate signal stored on the tape allows the calibration factor, lost in the recording process, to be restored by the 1921. The MAXIMUM LEVEL dB controls can be used to make the analyzer read out in decibels with the reference level of the original signal.

Many other tape recorders that have good dynamic range, frequency range, and stable characteristics are suitable for use with the 1921.

The 1525-A Data Recorder is supplied as a standard production unit by General Radio and is directly usable with the 1921.

Table 1-7
ACCESSORIES SUPPLIED

No. Supplied	*Description*	*GR Catalog Number*
1	Interconnecting cable, 36-pin male plug (Amphenol 57-30360) on each end; 1 ft. long. Connects 1925 output to 1926 input.	1921-0200
1	Power cable, 3-terminal 7 ft. long, to connect system to line power.	4200-9622
1	Power cable, 3-terminal, 1½ ft. long. to connect 1925 SWITCHED POWER connector to 1926 power input connector.	4200-1400
2	Connectors, 24 contacts, male (Amphenol 57-30240).	4220-3024
2	Connectors, 36 contacts, male (Amphenol 57-30360).	4220-3036
2	Connectors, 50 contacts, male (Amphenol 57-30500).	4220-3050

1.5.5 XY Plotter.

The HOUSTON INSTRUMENT Series 6400 OMNI-GRAPHIC$_{tm}$ recorders are recommended. They are general-purpose XY recorders having the unique advantage of using paper movement for an X variable, rather than the conventional technique of moving a beam across a fixed sheet of paper. The use of fan-fold paper having a series of independent grids gives the user sequentially presented XY plots. Each graph can be detached to yield a plot identical to that obtained from a standard XY recorder; or it can be kept in the fanfold sequence and referred to like a page in a book. Chart advance can be controlled manually, automatically or remotely. The paper movement can also be reversed, in order that repetitive trace plots can be run.

Conventional XY plotters can also be used with the 1921 Analyzer but they are not recommended because they require paper loading and, therefore, reduce the potential speed advantages of the analyzer system. The Houston 6420-024 and 6450-024 operate completely automatically with the 1921, which supplies appropriate pen-up, pen-down, and chart-advance signals to the recorder, as well as a 1-V, peak, X-axis sweep signal.

The Houston recorders can be supplied by GR complete with suitable interconnecting cable and chart paper in conjunction with the 1921 Analyzer, or as part of a larger analyzer system; or they can be purchased directly from Houston Instrument.

1.5.6 Data Printer.

The MDS Franklin Series-800 HI-Speed Digital Printer records, on paper tape, a list of the band numbers and band levels supplied to it by the 1921 Analyzer. American Standard Band Numbers (S1.6) and levels in dB, with virtually any desired reference level, are printed.

The printer should be used when most accurate numerical data is desired. Time can be saved by printing band levels directly rather than reading them from a plotted curve.

The Analyzer supplies band-number and band-level information in BCD 1-2-4-8 code serially by band, with standard TTL-logic levels. Any data printer that has a capacity of seven columns or more and will accept the code and logic levels can be used with the analyzer. When a rapid succession of measurements is to be made and printed, it is important that the printer be fast. This minimizes the time needed to output data and maximizes the time available for measurement.

The MDS 800 PRINTER operates synchronously with the Analyzer in the REMOTE ADVANCE output mode at a speed of 12 lines per second. Thus, a thirty-band measurement is printed in less than 3 seconds.

The printer can be supplied by GR complete with a suitable printing format and interconnecting cable in conjunction with a 1921 Analyzer, or as part of a larger system, or it can be purchased directly from Mohawk Data Sciences.

1.5.7 IBM Card Punch Coupler.

The Type 1791 Card-Punch Coupler is used to transfer data from digital measurement devices to an IBM 526 Printing Summary Punch, which then records the data automatically to punched cards. The coupler converts the parallel BCD information from the measurement device to the serial 10-line contact closures required by the punch. In addition to the punch, parallel data-processing instruments (data printers, etc.) can be connected to the coupler.

A coupler for use with the Analyzer can be supplied by GR.

1.5.8 Computer Equipment.

The Digital Equipment Corporation Programmed Data Processor - 8/L (PDP-8/L) is a small-scale general-purpose computer. The PDP-8/L is a one-address, fixed-work-length, parallel computer using 12-bit, two's complement arithmetic. Cycle time of the 4096-word random-address magnetic-core memory is 1.6 μs. Standard features of the system include indirect addressing and facilities for instruction skipping and program interruption as functions of input-output device conditions.

A small digital computer used in conjunction with the 1921 Analyzer can perform any or all of four basic functions:

1. Analyzer Control - The computer can be programmed to select all functions that are normally controlled manually with front-panel controls.
2. Rapid Data Storage - The computer can ingest the results of a measurement in about 1 ms, thus freeing the analyzer to make another. The stored results of the series of measurements are then typed out from the computer.
3. Comparison - The computer can compare the results of a measurement with a stored reference spectrum and make a decision, depending on their relation. For example, a noisy device can be rejected when its spectrum exceeds limits. The computer can also be programmed to provide information as to where limits have been exceeded, by what amount, and the probable cause.
4. Data Reduction - The computer can be used to reduce the spectral information from the analyzer to obtain various ratings. For example, programs can be supplied to find loudness level, speech-interference level, and other ratings.

Complete Analyzer/Computer systems, including suitable interface hardware, can be supplied by GR.

1.5.9 Line-Voltage Regulator.

The accuracy of measurements accomplished with precision electronic test equipment operated from ac line sources can often be seriously degraded by fluctuations in primary input power. Line-voltage variations as much as ±5% are commonly encountered, even in laboratory environments. Although most modern electronic instruments incorporate some degree of voltage regulation, possible power-source problems should be considered for every instrumentation set-up. The use of line-voltage regulators between power lines and the test equipment is recommended as the only sure way to rule out the effects on measurement data of low line voltage, transients, and other power phenomena.

The General Radio Type 1591 Variac® Automatic Voltage Regulator is a compact and inexpensive equipment capable of holding ac line voltage within 0.2% accuracy for up to a rack full of solid-state instrumentation. The 1591 possesses a basic capacity of 1 kVA with no distortion of the input waveform. This rugged electro-mechanical regulator comes in bench or rack-mount versions, both of which permit direct plug-in of measurement-instrument power cords.

1.6 PATCH CORDS AND ADAPTORS.

A wide variety of GR patch cords is available, as well as a full line of adaptors to convert the terminals for use with most commercial and military connectors. Some of these are listed in Table 1-8.

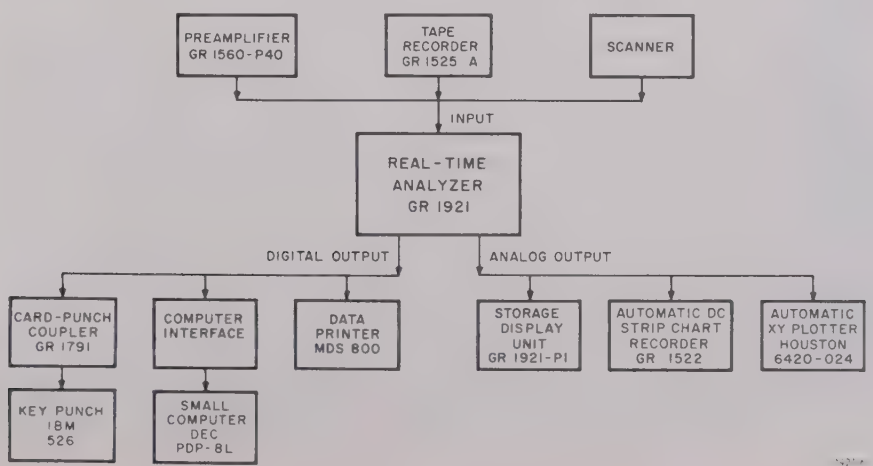
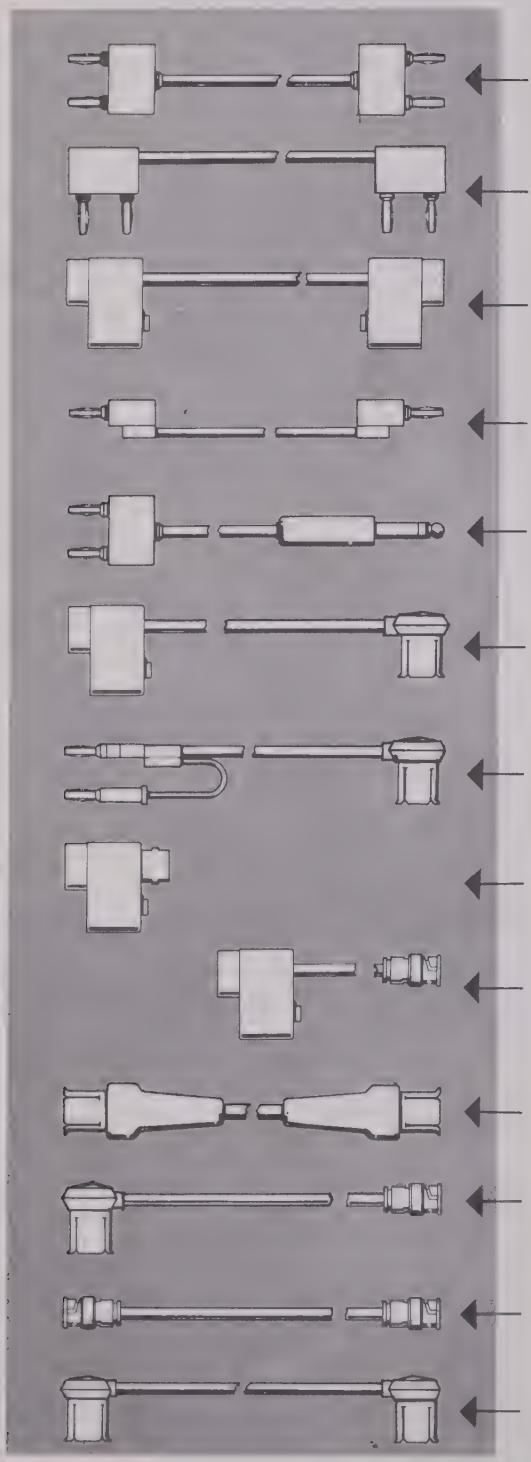


Figure 1-3. The 1921 is compatible with many accessory instruments.

Table 1-8

AVAILABLE INTERCONNECTION ACCESSORIES



TYPE NO.	DESCRIPTION	CATALOG NO.
274-NQ	Double-plug patch cord, in-line 36" long	0274-9860
274-NQM	Double-plug patch cord, in-line 24" long	0274-9896
274-NQS	Double-plug patch cord, in-line 12" long	0274-9861
274-NP	Double-plug patch cord, right-angle 36" long	0274-9880
274-NPM	Double-plug patch cord, right-angle 24" long	0274-9892
274-NPS	Double-plug patch cord, right-angle 12" long	0274-9852
274-NL	Shielded double-plug patch cord, 36" long	0274-9883
274-NLM	Shielded double-plug patch cord, 24" long	0274-9882
274-NLS	Shielded double-plug patch cord, 12" long	0274-9862
274-LLB	Single-plug patch cord, black, 36" long	0274-9468
274-LLR	Single-plug patch cord, red, 36" long	0274-9492
274-LMB	Single-plug patch cord, black, 24" long	0274-9847
274-LMR	Single-plug patch cord, red, 24" long	0274-9848
274-LSB	Single-plug patch cord, black, 12" long	0274-9849
274-LSR	Single-plug patch cord, red, 12" long	0274-9850
1560-P95	Adaptor cable, double-plug to telephone plug, 36"	1560-9695
874-R34	Coaxial patch cord, double plug to GR874, 36" long	0874-9692
874-R33	Coaxial patch cord, two plugs to GR874, 36" long	0874-9690
274-QBJ	Adaptor, shielded double plug to BNC jack	0274-9884
776-A	Patch cord, shielded double plug to BNC plug, 36" long	0776-9701
874-R22A	Coaxial patch cord GR874 to GR874, 36" long	0874-9682
776-B	Patch cord, GR874 (right-angle) to BNC plug, 36" long	0776-9702
776-C	Patch cord, BNC plug to BNC plug, 36" long	0776-9703
776-D	GR874 to GR874, both right-angle, 36" long	0776-9704

2-69

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Installation—Section 2

2.1 DIMENSIONS 2-1
2.2 MOUNTING 2-1
2.3 POWER-LINE CONNECTION 2-2
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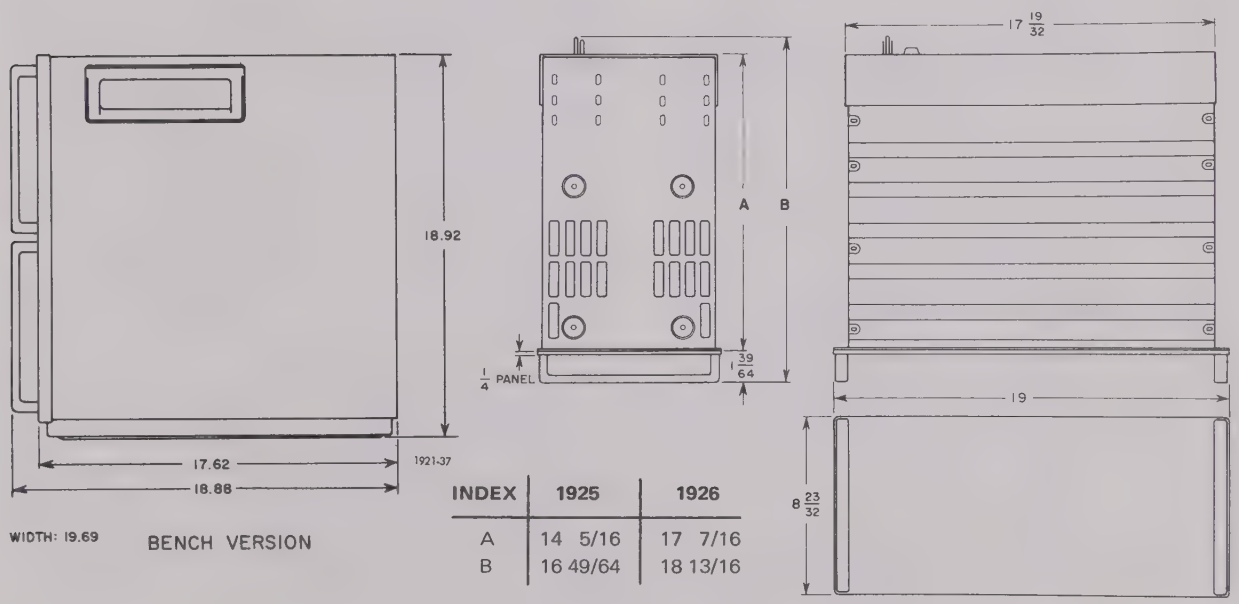
2.6 SET-UP INSTRUCTIONS 2-3
2.7 INSTALLING ACCESSORY INSTRUMENTS 2-4
2.8 USE OF FRONT-PANEL CONTROL COVER 2-4



INDEX	1925	1926
A	14 5/16	17 7/16
B	16 49/64	18 13/16

Figure 2-1. Dimensions of the Analyzer, in inches.

2.1 DIMENSIONS.

The dimensions of the 1921 components are given in Figure 2-1. The 1921 bench cabinet is 19 x 20 x 17½ in. (h, w, d), over-all.

2.2 MOUNTING.

2.2.1 System Cabinet.

The 1921 is delivered completely assembled in a system cabinet, P/N 4177-1921. To remove either the 1925 Multi-filter or the 1926 RMS Detector from the cabinet, first disconnect all cables from the rear panel connectors. Then insert a Phillips-head screwdriver through the holes in the front-panel handles of the instrument and remove four No. 10-32, 9/16-in. screws (two through each handle) with their nylon washers. Pull the instrument forward, out of the cabinet.

To reinstall either the 1925 or the 1926 in the system cabinet, place the rear edge of the instrument in the cabinet, so that the rear slide blocks engage the tracks on both sides. Slide the instrument into the cabinet; make sure that the front slide blocks also engage the tracks. Lock the instrument in the cabinet with four panel screws (No. 10-32, 9/16-in.) with nylon washers.

Table 2-1

ITEMS IN HARDWARE SET P/N 4174-2000

Fig. 2-2 Ref.	*No. Supplied*	*Item*
D	2	Brackets, L-shaped, P/N 4171-8520
E	8	Screws, binder-head, 10-32, 1/2 in., NP for rear support and rear bracket.
	8	Washers, flat, No. 10 } for use with
	8	Washers, locking, No. 10 } above screws,
	8	Nuts, hex, 10-32 } where necessary
F	4	Screws, pan-head, thread-cutting, 10-32, 1/2 in. for rear bracket where required.

2.2.2 Conversion to Relay-Rack Mount.

To convert the bench model of the 1925 Multifilter for relay-rack use, refer to paragraph 2.2.3 of the 1925 Instruction Manual.

The 1926 RMS Detector, when ordered separately, is delivered in a rackable cabinet assembly (P/N 4174-3685). Installation procedure is given below.

2.2.3 Relay-Rack Installation.

Relay-rack models of the 1925 and 1926 are both supplied with Hardware Set P/N 4174-2000 (refer to Table 2-1). Rackable Cabinet Assemblies are also supplied, P/N 4174-3165 for the 1925 and P/N 4174-3685 for the 1926.

To install a rack-model of either instrument in an EIA standard RS-310 19-in. relay rack, with universal mounting-hole spacing, proceed as follows:

a. Remove the four panel screws (A, Figure 2-2) slide the instrument forward, out of the rack cabinet, until it stops. Raise the front edge slightly to release the stops. The instrument can then be completely removed from the rack cabinet.

b. From the rear, remove the rear-cover screws (B) holding the rear cover to the rack cabinet and remove the cover.

c. Insert the rack cabinet in the rack and secure it to the front rails of the rack with four front-support screws (C).

d. If the rack contains a rear support, attach the brackets (D) to the rack cabinet, using the rear support screws (E), with washers and nuts, through the clearance holes in the bracket. Insert the screws from inside the rack cabinet. Use the set of slots in the cabinet that properly aligns clearance holes in the brackets with threaded holes in the rear rail of the relay rack.

e. Secure the brackets to the rear rails, using the rear-bracket screws (F).

f. Place the rear edge of the instrument in the rack cabinet so that the rear slide blocks (G) engage the track. Slide the instrument into the cabinet, making sure that the front slide blocks also engage the tracks. Lock the instrument in the cabinet with the four panel screws (A) with nylon washers. (Tighten these screws by inserting a Phillips-head screwdriver through the holes in the handles.)

g. Replace the rear cover and lock it in place using the rear-cover screws (B).

By removing the four panel screws (A), one can slide the instrument forward, out of the rack cabinet on the extendable tracks (see Figure 2-2). The tracks will still support instrument for easy access to its interior.

2.3 POWER-LINE CONNECTION.

With the Analyzer in the desired position, set the recessed slide switches, one on the 1925 and one on the 1926 (11 and 19, Figure 1-2) to the range corresponding to the power-line voltage to be used.

System power is controlled by the 1925 Multifilter. Connect a 3-terminal power cable (P/N 4200-1400,

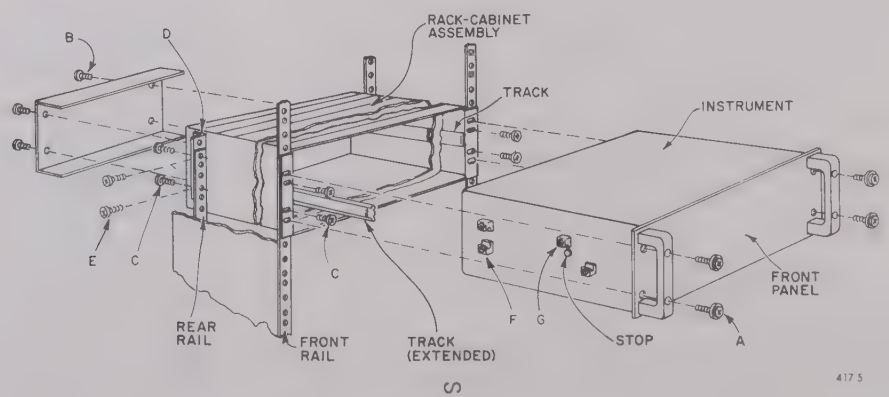


Figure 2-2. Method of mounting the 1925 or 1926 in a standard 19-in. relay rack.

supplied, 1 ½ feet long) from the SWITCHED POWER socket on the 1925 to the male line-power connector on the 1926. Direct line power is then applied only to the 1925, using the 3-terminal power cable, P/N 4200-9622 (7 feet long). Power to both instruments is controlled by the front-panel POWER switch on the 1925. The SWITCHED POWER connector on the rear panel of the 1926 is used to connect a power cable to feed other instruments in the system.

Two Slo-Blo fuses are installed in extraction-post fuse holders in the 1925 and the 1926. In the 1925, a 3/10-A fuse (F501) is effective for both 115- and 230-V operation and a 15/100-A fuse (F502) is effective for 230-V operation. In the 1926, a 1 6/10-A fuse (F1) is effective for both 115- and 230-V operation and an 8/10-A fuse (F2) is effective for 230-V operation only.

2.4 GROUNDING.

In "systems" installations, where several instrument chassis are in electrical contact, it is important that the signal currents follow well-defined paths. Two two-position slide switches (9 and 15, Figure 1-2, labelled CHASSIS CONNECTION TO CIRCUIT GROUND) on the rear panels of the 1925 and 1926, respectively, permit either a direct connection of the instrument chassis to the circuit ground or separation of the chassis from the circuit ground by insertion of a 10-Ω resistance. If crosstalk or hum is troublesome, use of the THROUGH 10 Ω position may eliminate the problem. The 10-Ω value is high enough to prevent signal currents from being conducted through the chassis, and is low enough to provide good cabinet shielding. Set the 1925 on DIRECT and the 1926 to 10 Ω. When other instruments are added to the analyzer system, it may be necessary to set the 1925 switch to 10 Ω also.

2.5 INTERFERENCE FROM STRAY FIELDS.

The Analyzer is susceptible to interference from the strong electric or magnetic fields sometimes generated by devices being used nearby. The possibility of interference should be kept in mind when the Analyzer is installed near other equipment. To reduce the interference, increase the spacing between the instruments or change the orientation of the equipment. If the interference is extreme, additional magnetic or electric shielding of either the noise source or the Analyzer may be necessary.

2.6 SET-UP INSTRUCTIONS.

2.6.1 Cable Connections.

The bench model of the Analyzer is normally supplied fully assembled. If, for some reason, the cable connections have been disturbed, use the procedure given in the following paragraphs to reconnect them.

Between the 1925 Multifilter(s) and the 1926 RMS Detector:

a. Connect cable supplied (P/N 1921-0200, 36-pin male connector on each end) from CHANNEL OUTPUTS connector (SO920) on the 1925 to the CHANNEL INPUTS (TO 1925) connector (AJ6) on the 1926.

b. If a second 1925 is used in the system, connect cable supplied (P/N 1921-0200, 36-pin male connector on each

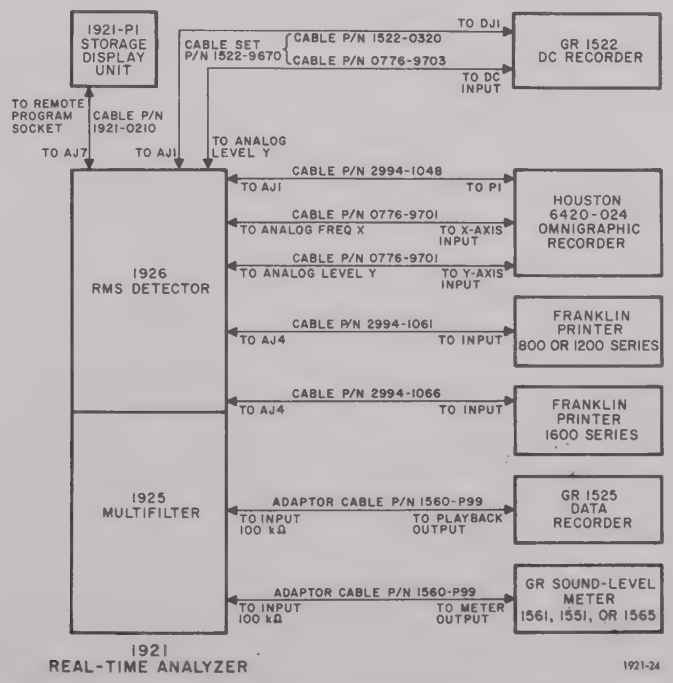


Figure 2-3. Patch cord interconnections to various accessory instruments.

end) from the CHANNEL OUTPUTS connector (SO920) of the second 1925 to the CHANNEL INPUTS (TO AUXILIARY 1925) connector (AJ5) on the 1926.

c. Connect a 3-terminal power cable (P/N 4200-9622, 7 ft. long, supplied) from the line power to the 3-terminal male input connector on the rear panel of the 1925.

d. Connect a 3-terminal power cable (P/N 4200-1400, 1 1/2 ft. long, supplied) from the SWITCHED POWER connector on the 1925 to the 3-terminal male input connector on the 1926. Power for both the 1925 and the 1926 is now controlled by the POWER switch on the 1925.

2.6.2 Input Connections.

Connect the signal to be analyzed to either the Cannon XLR-3-31 microphone socket or the BNC jack (both labelled INPUT 100 kΩ) on the 1925. The 3-terminal Cannon socket supplies +15 V at pin 2, to power the GR 1560-P40 Preamplifier.

Refer to paragraphs 1-5 and 3-5 for the use of input devices and remote-control signals.

2.7 INSTALLING ACCESSORY INSTRUMENTS.

The connections from the analyzer to various accessory instruments are shown in Figure 2-3. Other suitable equipment can, of course, be substituted for the ones shown. Refer to paragraph 3.4.9 and to the instructions supplied with each accessory instrument for the operating procedure of the combinations (Individual pin connections for the sockets on the 1926 are given in Figures 3-1 and 3-2 and in Tables 3-5 through 3-12.

2.8 USE OF FRONT-PANEL CONTROL COVER.

A protective cover (P/N 1926-1200) is supplied, to be placed across the lower portion of the front panel, to cover the controls and prevent accidental altering of their settings. The right-hand edge of the cover is slipped under the right-hand edge of the panel cutout so that the lower row of controls is concealed. To lock the cover in place, push the slide at the left end of the cover to the left; to unlock it, push the slide to the right.

2.9 OUTPUT PEAK MONITOR SWITCH.

A slide switch marked OUTPUT PEAK MONITOR, on the rear panel of 1925 instruments with ID numbers of 2956 or higher, disconnects the PEAK MONITOR meter when the switch is in the OFF position. When the 1925 is used with the 1926 (as in the 1921), the switch should remain in the OFF position.

Operation – Section 3

3.1 GENERAL. 3-1
3.2 MEASUREMENT PHASE 3-1
3.3 OUTPUT PHASE 3-8
3.4 REMOTE CONTROL 3-9
3.5 USE OF ACCESSORY INSTRUMENTS. 3-22

NOTE

Refer to Section 3 of the Instruction Manual for the 1925 Multifilter (included in this book) for the complete operating instructions for that instrument.

3.1 GENERAL.

The 1921 Real-Time Analyzer has many combinations of input and output controls to suit a great variety of applications. To simplify the use and explanation of these controls, it is best to consider separately the two functional phases, MEASUREMENT and OUTPUT, which occur for each operating cycle. (Refer to Tables 1-2, 1-3, and 1-4 for explanations of various control functions.)

During the MEASUREMENT phase, the INTEGRATING light is on in the 1926 and input signals are being measured and stored in a nondestructive memory. All possible input and calibration channels are measured (no matter what output settings are called for), and no outputs are available at this time. Duration of the MEASUREMENT phase is determined by the INTEGRATION TIME setting.

The MEASUREMENT phase is initiated by the START button. Successive initiations may be automatic, as selected by the MEASUREMENT MODE controls. If the STOP button is depressed, the MEASUREMENT phase is terminated and can be resumed only by use of the START button. (It is not recommended that PAUSE be used during the MEASUREMENT phase, because a measurement error may occur on the channel that is being measured at the time of pause.)

During the OUTPUT phase, the measurements are converted to decibels, when needed, for output presentation. No degradation of measured levels can occur during the OUTPUT phase. This phase may automatically repeat (if the SINGLE-HOLD MEASUREMENT MODE is used); otherwise a single presentation of the output data is made. The time duration of a single output presentation depends upon the output device being used and can be as short as 1 ms or as long as desired.

The PAUSE control is intended for use during the OUTPUT phase, so that an output device can be adjusted, or any output controls changed, without loss of the stored measurements.

3.2 MEASUREMENT PHASE.

3.2.1 Signal Input Connections.

Connect the input signal(s) to either the Cannon XLR 3-terminal microphone socket or the BNC coaxial jack, both on the rear panel, labelled INPUT 100 kΩ (on the 1925). A signal connected to either connector produces an output at one or all output connectors of the Multifilter (depending upon the frequency and the settings of the controls). The input impedance is 100 kΩ and peak voltages of ±17 V, referred to the dc component of the input signal, can be applied. The input dc component must not exceed (35 Vdc - peak Vac) for either polarity.

The outputs from all channels are available simultaneously at the 36-terminal CHANNEL OUTPUTS connector, SO920, on the 1925. The channels are numbered from 1 through 30 (refer to 1925 Instruction Manual). For versions of the 1925 that have adjustable attenuators, the

channel #1 attenuator is controlled by the thumbwheel on the extreme left of the front panel; the channel #30 attenuator is controlled by the thumbwheel on the extreme right. The channel number is distinct from the STANDARD BAND number, and any one of several filters can "occupy" any channel position.

Two sockets to connect input signals are located on the rear panel of the 1926. The CHANNEL INPUTS socket (AJ6) is used for the first 30 channels (see Figures 3-1 and 3-2). The auxiliary CHANNEL INPUTS socket (AJ5) has connections to the 15 high-numbered channels for the 45-channel version of the 1926 Detector and overlaps the channel connections to AJ6 for the middle 15 of 45 input channels.

The channels are numbered from 1 to 45 and are distinct from STANDARD BAND numbers, which apply to filter-frequency specifications. The BAND NUMBER, displayed at the output, may be different from the channel number, which is assigned at the input connector (refer to paragraph 3.2.2).

Figures 3-1 and 3-2 show the pin connections to the CHANNEL INPUTS connectors, AJ6 and AJ5, respectively. The GND connection ties to circuit ground and the CH GND connection ties to the chassis.

Input impedance is 5.1 kΩ and is capacitor coupled.

3.2.2 Band-Number Designation.

To facilitate interpretation of the output data, the serial input-channel numbering can be transposed to a different serial BAND numbering sequence. For example, the Type 1925 Multifilter utilizes STANDARD BAND numbers that identify the filter center frequencies. The 1926 Detector BAND NUMBER output sequence is adjusted to correspond to these numbers. The CALIBRATE channels are the two bands below the lowest 1925 Multifilter BAND number. The BAND NUMBER designation can be changed by the following procedure:

Thirty-Band Systems

Standard 1921 thirty-band systems have 30 active channels and two calibration channels.

The proper circuit connections for any particular version of the Multifilter are made on a patch board (P/N 1925-2740) located on the under side of the chassis. These connections are made before the instrument leaves the factory and no changes should be required. Table 3-1 lists the connections that must be made on etched-circuit board P of the 1926 to obtain the listed correspondences between the channels within the instrument and the band numbers by which they are identified to the outside. Note that, regardless of the connections made with the numbered leads, the lettered connections must be as follows:

H to K
A to B
E to F
L to N

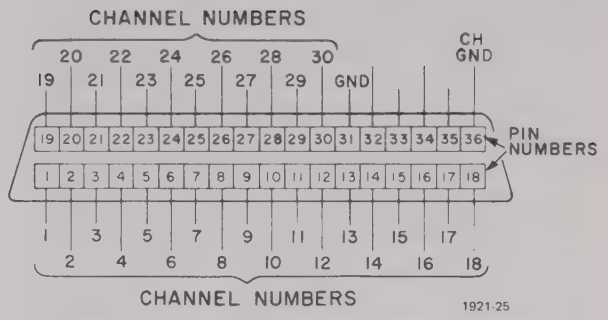


Figure 3-1. The first 30 channels connect as shown, to socket AJ6 of the 1926.

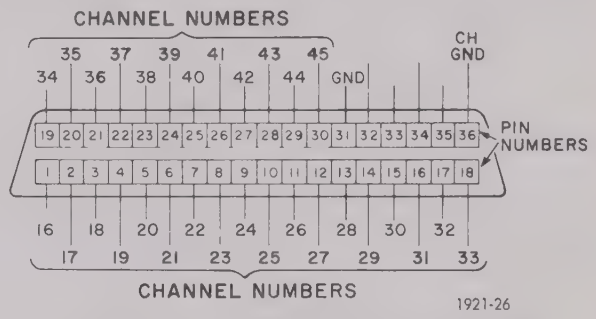


Figure 3-2. For the 45-channel versions, the upper 30 channels connect as shown, to socket AJ5 of the 1926.

To display the calibration channels, it is sometimes necessary to employ band numbers 62 and/or 63. While it may seem illogical, these bands must be addressed by the front-panel control marked LOWEST BAND NUMBER. For example, if the instrument is connected so that the first active channel is displayed as band 0, and it is desired to display both calibration channels and then bands 0 to 5, inclusive, the LOWEST BAND NUMBER control must be set for 62 and the HIGHEST BAND NUMBER control for 5.

Forty-five-band Systems.

Forty-five band systems have 45 active channels and two calibration channels. Table 3-2 lists the connections that must be made on etched-circuit board P to obtain the listed correspondences between the channels within the the instrument and the band numbers by which they are identified to the outside. Note that, regardless of the connections made with the numbered leads, the lettered connections must be as follows:

G to H
B to C
D to E
L to M

To display the calibration channels, it is sometimes necessary to employ band numbers 62 and/or 63. While it may seem illogical, these bands must be addressed by the front-panel control marked LOWEST BAND NUMBER.

Table 3-1

1926 P-BOARD WIRING—30-CHANNEL SYSTEM

Band Assignments					
Active Channels		*Calibration Channels*		*Connect Leads*	
1st	*30th*	*0 dB*	*60 dB*	*to + bus*	*To − bus*
0	29	63	62	1, 2, 3, 8, 14	10
1	30	0	63	1, 2, 3, 8, 10, 14	NONE
2	31	1	0	NONE	1, 2, 3, 8, 10, 14
3	32	2	1	10	1, 2, 3, 8, 14
4	33	3	2	8	1, 2, 3, 10, 14
5	34	4	3	8, 10	1, 2, 3, 14
6	35	5	4	3	1, 2, 8, 10, 14
7	36	6	5	3, 10	1, 2, 8 14
8	37	7	6	3, 8	1, 2, 10, 14
9	38	8	7	3, 8, 10	1, 2, 14
10	39	9	8	1	2, 3, 8, 10, 14
11	40	10	9	1, 10	2, 3, 8, 14
12	41	11	10	1, 8	2, 3, 10, 14
13	42	12	11	1, 8, 10	2, 3, 14
14	43	13	12	1, 3	2, 8, 10, 14
15	44	14	13	1, 3, 10	2, 8, 14
16	45	15	14	1, 3, 8	2, 10, 14
17	46	16	15	1, 3, 8, 10	2, 14
18	47	17	16	2	1, 3, 8, 10, 14
19	48	18	17	2, 10	1, 3, 8, 14
20	49	19	18	2, 8	1, 3, 10, 14

For example, let us assume we have a 30-channel 1926 Detector and a 1/3-octave 1925 Multifilter, covering the frequency range of 3.15 Hz to 20 kHz. The standard-band number for 3.15 Hz is 5. From Table 3-1, the 30th active channel is band number 34 (which corresponds to 20 kHz for 1/3-octave filters). Then, from the table, the calibration channels are 4 and 3, the + bus leads are 8 and 10, and the -bus leads are 1, 2, 3, and 14.

Table 3-2

1926 P-BOARD WIRING—45-CHANNEL SYSTEM

Band Assignments				*Connect Leads*	
Active Channels		*Calibration Channels*			
1st	*45th*	*0 dB*	*60 dB*	*to + bus*	*to − bus*
0	44	63	62	1, 2, 3, 8, 14	10
1	45	0	63	1, 2, 3, 8, 10, 14	NONE
2	46	1	0	NONE	1, 2, 3, 8, 10, 14
3	47	2	1	10	1, 2, 3, 8, 14
4	48	3	2	8	1, 2, 3, 10, 14
5	49	4	3	8, 10	1, 2, 3, 14

For example, if the instrument is connected so that the first active data channel is displayed as band 1, and it is desired to display both calibration channels and then bands 1 to 7, inclusive, the LOWEST BAND NUMBER control must be set for 63 and the HIGHEST BAND NUMBER for 7.

To connect a 3-channel 1925 Multifilter to a 45-channel 1926 Detector, use the data given in Table 3-1.

3.2.3 Maximum Band-Level Calibration.

The MAXIMUM BAND LEVEL dB control changes the digital output numbers in 1-dB steps. It has no effect on the analog outputs and does not change the Analyzer sensitivity or gain adjustments. It is provided as a measure of referring measurements to some convenient reference source.

With the attenuators on the 1925 set to 0 dB, a full-scale 1-V input signal will produce a readout on the 1926 equal to the dB level setting of the MAXIMUM BAND LEVEL controls. The Analyzer readout covers a 60-dB range. Therefore, when the MAXIMUM BAND LEVEL control is set at 60 dB, the lowest possible readout is 0 dB. Similarly, if the MAXIMUM BAND LEVEL control is set at 90 dB, the lowest readout is 30 dB, etc. Thus, the Analyzer can be made direct reading relative to any reference desired.

Normally, the MAXIMUM BAND LEVEL control will be set to agree with the transducer characteristics. For example, if a microphone plus preamplifier is known to generate 0.1 V for a sound pressure of 110 dB, then the output would be 1.0 V for 130 dB. A 1.0-V value corresponds to full scale, so the MAXIMUM BAND LEVEL control would be set to 130 dB.

3.2.4 Selection of Integration Time.

INTEGRATION TIME is the period of time over which the input data is measured. Nine choices are provided, in octave steps, from 1/8 to 32 seconds.

The measurement sample rate or the number of samples taken is determined by the INTEGRATION TIME (refer to Table 3-3). The maximum average sample rate is 1024 samples per second per channel, and the maximum number of samples taken is 1024 per channel. Below one second, fewer samples are taken (at a rate of 1024 per second) and above one second the sample rate reduces while a total of 1024 samples is maintained.

The sampling times are varied during each measuring interval to prevent the possibility of sampling in phase with some particular input signal frequency. During the start of each measurement, the sampling times are quite close together, and become farther apart as the measurement progresses. Thus, the first 512 samples are taken in about 45% of the time, and the last 512 samples require about 55% of the time.

The practical consequence of this situation is that measurement times differ slightly from those marked on the front panel. The panel shows times in ratios of 2:1 from each other. This is valid for intervals of one second and greater. For less than one second, the 2:1 ratio is retained in panel marking as a reminder that the number of samples also decreases by 2:1 for each step in time down from 1 second. But the actual measurement times are as follows for instruments as normally calibrated at our factory:

NOMINAL TIME (seconds)	ACTUAL TIME (seconds)	NOMINAL TIME (seconds)	ACTUAL TIME (seconds)
1/8	0.100	4	4.118
1/4	0.208	8	8.235
1/2	0.449	16	16.470
1	1.029	32	32.940
2	2.059		

Table 3-3
INTEGRATION-TIME PARAMETERS

Integration Time—Seconds	1/8	1/4	1/2	1	2	4	8	16	32
No. of Samples Taken	128	256	512	1024	1024	1024	1024	1024	1024
Avg. Sampling Rate	1024	1024	1024	1024	512	256	128	64	32
Avg. Sample Spacing—ms	0.781	0.813	0.877	1.00	2.01	4.02	8.04	16.08	32.2
80% Confidence Limits for Independent Samples (Noise Input) — ± dB	0.5	.34	.24	.17	.17	.17	.17	.17	.17

Minor adjustments to these times are possible. For example, the master clock of the instrument can be speeded up a trifle by turning the adjusting screw on the variable inductor of etched circuit board M in the counterclockwise direction.

For measuring random signals, the greatest accuracy is obtained when the sample spacing exceeds the signal correlation time. Correlation time is defined as the minimum time spacing between independent samples. Each sample is then statistically independent. The average sample spacing is also shown in Table 3-3.

An uncertainty is always associated with measurement of a random signal and is reduced as the number of independent measuring samples is increased. This phenomenon is due to the source (and not the 1926 Detector) and is expressed by the 80% confidence limits shown in Figure 3-3. These limits apply for independent measurement samples of a random input signal having a Gaussian amplitude probability distribution.

A very long correlation time may result in less than 100 independent samples, for a random input. Figure 3-3 is a guide to the variation in measurement that is to be expected for a random signal with a Gaussian distribution. On the average, 80% of all measured values will lie within the bounds of Figure 3-3.

Short-Duration Input Signals.

For input data of limited duration, the INTEGRATION TIME should, ideally, be slightly shorter than the data duration. A slight overlap of data duration allows for synchronization of the start of input data and the start of the MEASUREMENT PHASE.

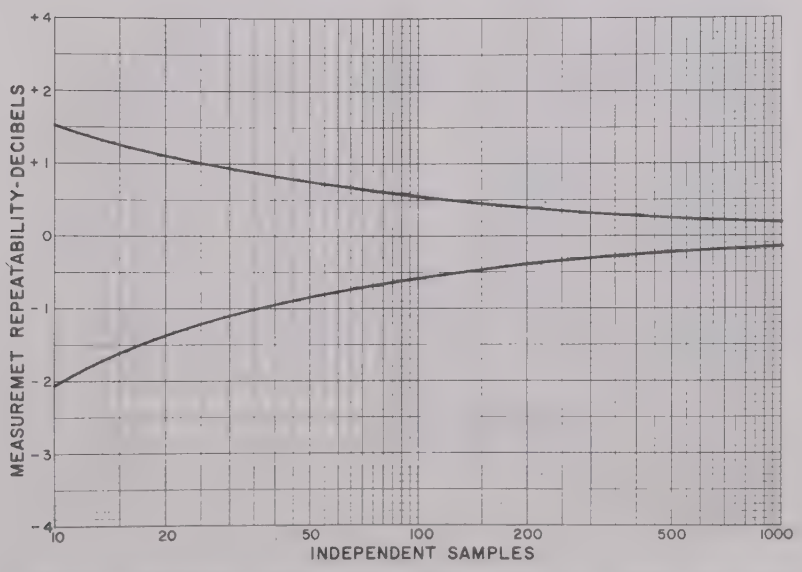


Figure 3-3. Measurement bounds for 80% confidence limits with a Gaussian noise source.

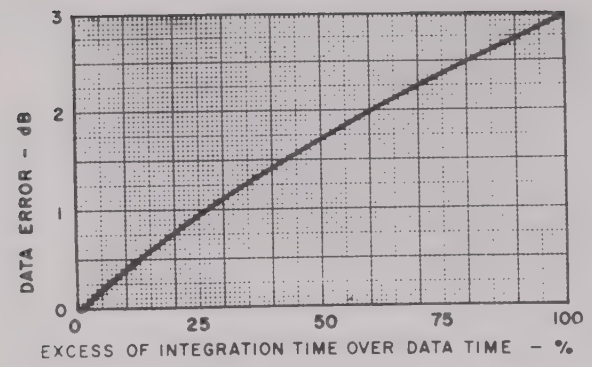


Figure 3-4. Approximate data correction for excess integration time.

If the INTEGRATION TIME is longer than the data duration, some samples will be taken when there is zero input and the resulting measured value will be low. For example, suppose the INTEGRATION TIME is twice the duration of the input data and half of the samples are taken with zero input. The resulting measurement will be 3 dB lower than the data rms level but, of course, will be true value for the signal level presented to the 1926 Detector, during its integration period.

It is important that the start of the MEASUREMENT PHASE be accurately synchronized to the start of the input data for short-duration signals. Also, if the INTEGRATION TIME is longer than the input data, a correction must be applied to compensate for a partly zero input. Figure 3-4 is a plot of the approximate correction versus excess integration time. Such a correction should be based on percent of samples missed (rather than percent INTEGRATION TIME) to be accurate. This is not feasible, however, since the sample spacing is non-uniform in time.

Steady-state input signals. No synchronization problem exists for input signals of unlimited duration; the choices of INTEGRATION TIME and START of the MEASUREMENT PHASE are dictated by other considerations.

Maximum measurement accuracy is achieved for INTEGRATION TIME of 1 second and longer (refer to Table 3-3). However, some knowledge of the input-signal correlation time (independent sample time) is necessary before this choice can be made. The average sample spacing should be greater than the correlation time if a maximum number of independent samples is to be taken.

The variation of the 80% confidence limits indicated by Table 3-3 is small (for the number of independent samples shown) and this is, perhaps, a minor point for consideration. However, for the common case where measurements are being made of a relatively narrow band of noise, the input signal will have a rather long correlation time. A long INTEGRATION TIME may be necessary to obtain even 100 ***independent*** input samples.

Figures 3-5 and 3-6 are excellent illustrations of the measurement uncertainties associated with having a small number of independent samples. The curves (80% and 99% confidence limits, respectively,) represent what is obtainable from a 1/3-octave filter (such as the 1925 Multifilter) for INTEGRATION TIME of the 1926 Detector of 32, 1, and 1/8 seconds. At low frequencies, where the correlation time is long, it is seen that the measurement uncertainty is relatively large.

The average rate of sampling for the 1926 Detector is below the maximum frequency range of 100 kHz. A low sample rate is of no consequence for the sake of rms-level measurements but would be an important consideration if we were attempting to reconstruct an input signal (sampling would have to be at or above the Nyquist rate). What is of importance is avoiding coherence between an input-signal frequency and an integral multiple of the sampling frequency. This possibility is avoided by modulating the sampling rate (refer to paragraph 4.2).

3.2.5 Input-Signal Duration.

Input signals to the 1926 Detector are sampled at discrete instants of time. Signal levels that occur between sample instants do not affect the measured result. A minimum time duration for pulse or transient signals must be imposed, therefore, to ensure that several sampling instants will coincide with signal peaks.

Average spacing between samples is a parameter that depends upon integration time, as shown in Table 3-3. A safe limit for minimum signal duration equals 10 times the average sample spacing and is, therefore, 10 ms.

A pulsed input signal will not coincide with all sample instants and several measurements of zero signal level will occur, effectively reducing the number of samples per measurement period. It should be remembered that measurement repeatability decreases as the number of signal samples is reduced.

3.2.6 Measurement Mode.

There are three MEASUREMENT MODE controls on the 1926, designated SINGLE, SINGLE-HOLD, and MULTIPLE. The SINGLE mode uses one measurement phase and one output phase. This mode must be initiated by a START command and is terminated automatically when the OUTPUT is complete.

The SINGLE-HOLD mode uses one MEASUREMENT PHASE and a continuous sequence of OUTPUT PHASE operations. For example, the SINGLE MODE is used when the output data is recorded (printer or X-Y plotter) and hence is already available for unlimited operation. The SINGLE-HOLD mode is used when only one measurement is needed or can be taken (e.g., transient data) and it is desired to store the measurement in memory for continuous output (for multiple printer or X-Y copies, etc), or for use with a non-store oscilloscope.

The MULTIPLE mode is a continuous sequence of single

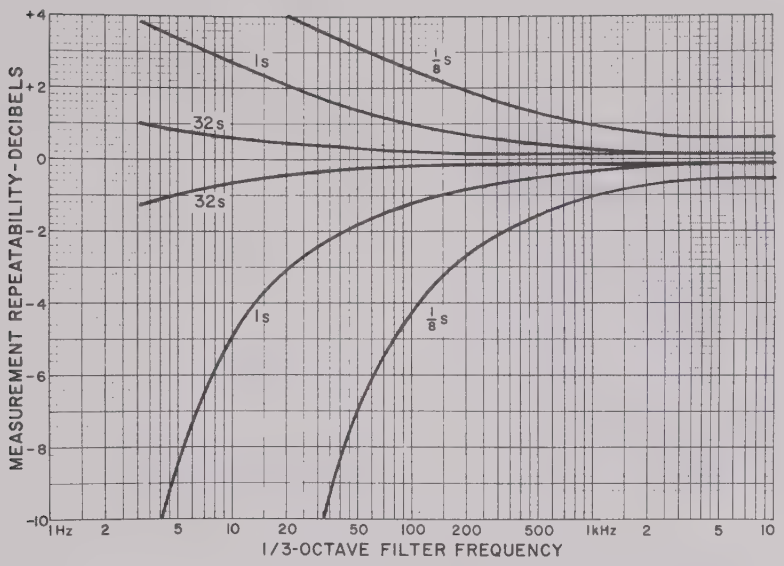


Figure 3-5. Confidence limits (80%) for a white Gaussian noise input.

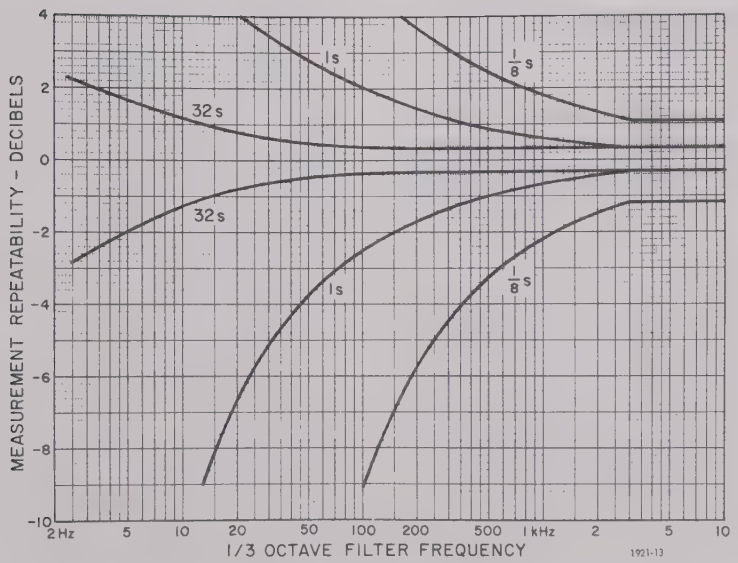


Figure 3-6. Confidence limits (99%) for a white Gaussian noise input.

mode operations. It is initiated by a START command and is terminated by a STOP command.

The MULTIPLE MODE is used when continuous observation (real-time operation) of input data is desired.

3.3 OUTPUT PHASE.

3.3.1 Display.

Bands Displayed. In the MEASUREMENT MODE, all possible input channels are measured and stored in memory. Only those channels of interest are presented as outputs, however, during the **Output Phase**.

Output data is always presented in sequence by **Band Number**. Control of the bands displayed is determined by setting the LOWEST BAND NUMBER and the HIGHEST BAND NUMBER controls to include the desired channels.

Display Rate. The rate of data output from the 1926 Detector can be controlled in one of three ways:

1. Automatically, at a pre-selected DISPLAY RATE;
2. Manually, using the MANUAL ADVANCE;
3. By remote command, using the REMOTE ADVANCE.

The DISPLAY RATE control is used to pre-select a display rate for the OUTPUT DISPLAY modes of X-Y PLOT and PRINTER.

NOTE

DISPLAY RATE is inoperable for any of the OSCILLOSCOPE DISPLAY modes, which use a fixed display rate of 1 ms per band. A reset time of 0.5 s is provided at the start of each X-Y plot output to allow for erasing of a storage oscilloscope.

For REMOTE ADVANCE, an external advance command pulse is required for each band displayed (except the first band). The highest display rate possible in this mode is 15 ms per band. There is no limit to how slowly the data can be displayed.

3.3.2 Use of Calibration Channels.

Two extra channels (with no external connections) are provided for automatic calibration of full-scale and zero levels. They are measured during every measurement phase and are available to be displayed, if desired. The calibrate channel positions precede the first input channel; the full-scale is first and the bottom-scale follows.

To display the calibrate channels, set the LOWEST BAND NUMBER control to the lowest input band number minus two. For example, if the first input channel is designated as band number 11, set the LOWEST BAND NUMBER control to 9. If the first input channel is band number 1, however, set the LOWEST BAND NUMBER control to 63.

The calibrate channels can be used as a self-check feature to continuously monitor the operation of the 1926 Detector or to record the setting of the MAXIMUM BAND LEVEL dB control. In this case, calibrate channels would be displayed during each output phase.

In addition, the calibrate channels are used to calibrate an analog output device, such as an XY plotter or oscilloscope. For this application, the 1926 Detector is first operated for one measurement with the following control settings:

LOWEST BAND NUMBER — "full-scale" calibrate channel
HIGHEST BAND NUMBER — "bottom-scale" calibrate channel
MAXIMUM BAND LEVEL dB — 60
PANEL DISPLAY — on
INTEGRATION TIME, SECONDS — 1
MEASUREMENT MODE — SINGLE - HOLD
OUTPUT DISPLAY — XY PLOT or PRINTER
DISPLAY RATE — MANUAL ADVANCE

The first band displayed should read 60 dB and is used to set the output-device 60 dB point. Next press the MANUAL ADVANCE button; the panel display should read 0 dB. Then, set the output deivce for zero scale.

3.3.3 Output Devices.

Oscilloscope. (Refer to separate instructions for the 1921-P1 Storage Display Unit.) Three operating modes are provided for oscilloscope use and are: STORE-ERASE, STORE-NO ERASE, and NON STORE. Their functions are self explanatory and follow the designations with regard to STORE for storage oscilloscope and ERASE for erasure of a storage oscilloscope pattern. Display rate is fixed at 1 ms per channel for oscilloscope display. Retrace time of the X-axis output is 0.5 ms. Always connect the oscilloscope to pins 1 and 21 on connector AJ7 of the 1926 (***not*** to the ANALOG FREQ X and ANALOG LEVEL Y terminals). A 5000-pF capacitor placed across the input terminals to the scope will help to eliminate any distortion in the signal.

A storage command appears as a 15-V level at the oscilloscope output connector (AJ7). Erase command is a 15-V pulse of 0.5-second duration, and occurs at the start of the OUTPUT phase.

X-Y Plot. The X-Y PLOT button engages the DISPLAY RATE control and enables the control signals for pen lift and page advance. A suitable display rate for the Houston Type 6420-024 Plotter is two bands per second. During the page-advance period (0.5 s), the pen is commanded to lift.

Recorder. The GR Type 1522 DC Recorder is operated by REMOTE ADVANCE. The 1522 supplies a signal to the 1926 for band advancing, so that the output data can be recorded at a rate limited by the writing speed of the 1522.

Multiple-Output Devices. The 1926 Detector output has serial access (by channel) to the stored measurement data during the OUTPUT PHASE. Hence, if multiple DISPLAY RATE settings are desired for multiple-output devices, they must be obtained sequentially, using the SINGLE-HOLD MEASUREMENT MODE.

Table 3-4
OUTPUT-DISPLAY CONTROL FUNCTIONS

	Display Rate Bands/ms	*Reset Time*	*X*	*Y*	*Erase*	*Store*	*Print Command*	*Pen Up Command*	*Page Advance*
OSCILLOSCOPE STORE-ERASE	1	0.5 ms	0	0	1	1	0	0	0
STORE–NO ERASE	1	1 ms	0	0	0	1	0	0	0
NON-STORE	1	1 ms	0	0	0	0	0	0	0
X-Y PLOT	VARIABLE (1-64 bands/s in binary sequence)	0.5 s	1	1	0	1	1	1	1
PRINTER	VARIABLE (1-64 bands/s in binary sequence)	1 ms	0	0	0	1	1	0	0
REMOTE ADVANCE	EXTERNAL	EXTERNAL	1	1	1	1	1	1	1

Many devices can be operated simultaneously, as listed below:

1. X-Y Plotter, Printer, Nixies, Storage Oscilloscope.
2. Printer, Nixies, Storage Oscilloscope.
3. Storage Oscilloscope, Computer.

For the first combination, the X-Y PLOT mode is used, because this mode provides a 0.5-s period for resetting or reloading paper. The DISPLAY RATE must be set to accomodate the slowest device. All necessary control signals are available (refer to Table 3-4).

For the second combination, the PRINTER mode is used. If it is desired to control the display rate externally, however, the REMOTE ADVANCE mode is used and the display rate can be controlled by the printer.

Table 3-4 illustrates the signals and control functions that are activated for each setting of the OUTPUT DISPLAY. A signal or control command is not available, as indicated by a 0; or it is available, as indicated by a 1.

To use an oscilloscope and a computer, set the OUTPUT DISPLAY OSCILLOSCOPE to either STORE-NO ERASE or NON-STORE. (The STORE-ERASE mode requires an extra 0.5 s for erasing.) This will provide a 1-ms-per-band DISPLAY RATE, which is compatible with both devices. A signal from the computer that says it has not read or is reading the data can be used to remotely command a PAUSE, to ensure that all data will be read by the computer.

3.4 REMOTE CONTROL (Refer to par. 3.4.8).

3.4.1 General.

All functions except the PANEL DISPLAY lamp switch and DISPLAY RATE – BANDS PER SECOND are capable of being programmed from voltage levels on the rear-panel connectors. The requirements for this control are listed below.

NOTE

The word "ground" means either to connect to circuit ground or reduce the potential below ≈ 0.25 V by any other means, such as a saturated transistor or an integrated circuit capable of sinking about 1.6 mA.

3.4.2 Lowest Band Number.

Set front-panel thumbwheel switches to blank, 0. Then–

For TENS, ground as follows:

0–9	No Grounds
10–19	AJ2–38
20–29	AJ2–39
30–39	AJ2–38 and AJ2–39
40–49	AJ2–13

For UNITS, ground as follows:

0	No Grounds
1	AJ2–36
2	AJ2–37
3	AJ2–36 and AJ2–37
4	AJ2–11
5	AJ2–11 and AJ2–36
6	AJ2–11 and AJ2–37
7	AJ2–11 and AJ2–37 and AJ2–36
8	AJ2–12
9	AJ2–12 and AJ2–36

3.4.3 Highest Band Number.

Set front-panel thumbwheel switches to blank, 0. Then—

For TENS, ground as follows:

0–9	No Grounds
10-19	AJ2–42
20–29	AJ2–43
30–39	AJ2–43 and AJ2–42
40–49	AJ2–17

For UNITS, ground as follows:

0	No Ground
1	AJ2–40
2	AJ2–41
3	AJ2–40 and AJ2–41
4	AJ2–15
5	AJ2–15 and AJ2–40
6	AJ2–15 and AJ2–41
7	AJ2–15 and AJ2–41 and AJ2–40
8	AJ2–16
9	AJ2–16 and AJ2–40

3.4.4 Integration Time - Seconds.

Press the front-panel button marked REMOTE within the button group headed INTEGRATION TIME – SECONDS. This enables the external control over integration time. Now ground the following terminals:

1/8 s	AJ2–5 and AJ2–30
1/4 s	AJ2–5 and AJ2–31
1/2 s	AJ2–5 and AJ2–32
1 s	AJ2–5
2 s	AJ2–6
4 s	AJ2–7
8 s	AJ2–8
16 s	AJ2–9
32 s	AJ2–10

3.4.5 Measurement Mode.

To control MEASUREMENT MODE from external signals, press the SINGLE-HOLD (REMOTE) button. Then ground the following pin connections:

For SINGLE, ground AJ2-3

For SINGLE-HOLD, no grounds

For MULTIPLE, ground AJ2-28

3.4.6 Stop–Start–Pause.

To stop operations, ground either of the following for at least 250 ns: AJ2-2 or AJ3-18.

This is a permanent stop. Operation is killed completely, and the only way to resume operation is to begin from the beginning with a new start.

To START operations, ground AJ2-26 for at least 250 ns.

To PAUSE, ground AJ2-44. The PAUSE condition continues as long as this terminal is grounded. Removing the ground (or returning the voltage on this terminal to between +3 and +5 V) restores operation within 0.5 ms.

3.4.7 Output Display.

General. The selection of output display can be made by a contact to ground. First, it is necessary that none of the buttons in the OUTPUT DISPLAY group be depressed. To release all buttons, gently and slowly press any button that is not in. When the button being pressed is about half way in, the one already in will pop out. As soon as this happens, release the button being pushed before it latches into a pushed-in state.

Oscilloscope Store-Erase. Ground terminal AJ2-19 on the rear panel. The output will consist of the display of each channel in turn, starting with the LOWEST BAND NUMBER and ending with the HIGHEST BAND NUMBER. Each channel is displayed for approximately 1 ms. When the display is completed, the trace stored on the scope remains until 0.5 s before the next display sequence is to start, and is then erased automatically.

Oscilloscope Store - No Erase. Ground terminal AJ2-20 on the rear panel. The output will be displayed as described in the paragraph above, but erasure of the storage scope trace does not occur.

Non-Store. Ground terminal AJ2-21 on the rear panel. In this mode of operation, the storage and erase features are both disabled. The time a trace remains on the screen is determined by the presistence of the phosphor. Display rate is 1 ms per channel. This mode is used with storage scopes when they are not to store, and with oscilloscopes that do not have storage capability.

X-Y Plot. This is a slow mode of display. It is achieved by grounding terminal AJ2-22 on the rear panel and setting the actual display rate in bands-per-second by means of the DISPLAY RATE–BANDS PER SECOND switch at the right-hand side of the front panel.

NOTE

The setting of this switch is not programmable from external voltages, currents, or contact closures.

A printer may also be used when the X-Y PLOT is enabled. If a scope is used simultaneously, the scope is programmed to STORE-NO ERASE.

Before the next display sequence can take place, a 0.5-s time interval is provided for advancing the plotter to the next sheet of paper, whether or not the particular plotter in use has automatic paper advance.

Printer. This is also a slow mode of display. Ground terminal AJ2-23 on the rear panel. The DISPLAY RATE-BANDS PER SECOND switch must be set for the desired display rate. Depending on the printer, this will usually be

2, 4, or 8. A scope may be used simultaneously, and is connected for STORE-NO ERASE.

Nixies. The Nixie tubes can be viewed only at relatively slow rates. The best choice for viewing Nixies is the PRINTER display (refer to paragraph above). If the printer is not wanted when viewing Nixies, it should be turned off.

Remote Advance. REMOTE ADVANCE is selected by grounding either AJ2-24 or AJ4-20. This display mode is intended for use with instruments that can "talk back," reporting, in effect, "I have processed the data you sent. Now give me a new band's worth of data." The talk-back signals must be of at least 250 ns duration, and provide transitions between nominal +5-V and 0-V levels.

CASE I. When talk-back signal is a pulse going to 0 V from a customary level of +5 V. Apply this pulse to either AJ1-9 or AJ4-19. Ground either AJ1-2 or AJ4-45.

CASE II. Report-back signal is a pulse going to +5 V from a customary level of 0 V. Apply this pulse to either AJ1-2 or AJ4-45. Both AJ1-9 and AJ4-19 must be open-circuited.

When REMOTE ADVANCE is selected, the display time per channel is controlled entirely by the external device. The only limitation is that the external device must not call for a new band more often than every 15 μs.

When REMOTE ADVANCE is selected, voltages are available for X-Y recorders (subject to note below), and the ERASE, STORE conditions are selected for a scope. PRINT commands are generated for a printer, and PEN DOWN and PEN UP commands for an X-Y plotter.

Since the external device controls the display time per channel, the voltage developed on the X-axis output terminals (the ANALOG FREQUENCY BNC connector) is unpredictable.

NOTE

If scopes or X-Y recorders are used simultaneously and an external device is controlling the display time, let it also generate the X-axis sweep voltage.

Manual Advance. The action of MANUAL ADVANCE may be achieved by external electrical commands. The OUTPUT DISPLAY mode must be either X-Y PLOT or PRINTER, because these are the only display modes in which MANUAL ADVANCE is possible. The X-Y PLOT or PRINTER modes can be initially established either by pushing the front-panel buttons or by making electrical connections as explained above. Once the mode is selected, set the DISPLAY RATE — BANDS PER SECOND switch to MANUAL. Then manual advance is accomplished either by pushing the MANUAL ADVANCE button or by momentarily (a few microseconds or more) grounding terminal AJ2-27 on the rear panel.

3.4.8 Option for 15-V Logic.

Etched-circuit board W is available on special order for use with printers and other devices requiring 15-V logic levels for the band number and band level dB.

3.4.9 Index of External Signals.

General. Tabulated below are external-control signal functions for the 1921 and signal interface data with respect to accessory instruments. All relate to rear-panel multipin connectors on the 1926 unit and are displayed in the reference designator order of the connectors.

As arranged in connector groupings, the data in the left-hand column are the signal-identifying codes used on the detail circuit schematics, next is the pin number location and finally the signal description.

NOTES

Each pin number is followed by an impedance code as follows:

— Essentially zero, as from emitter followers, power supplies, or ground connections.

* Output impedance of TTL integrated circuit, nonlinear, but about 25 to 100 ohms in low-voltage state and about 100 to 200 ohms in high-voltage state.

(Output impedance of DTL integrated circuit, nonlinear, but about 25 to 100 ohms in low-voltage state and about 6000 ohms in high-voltage state.

+ If instrument has board W designed for 15-V levels, output impedance is about 12,000 ohms in high-voltage state and 25 to 100 ohms in low-voltage state. If instrument has 5-V output levels, impedance corresponds to output impedance of TTL integrated circuit. See * listing for this impedance.

= Output impedance varies with setting of internal voltage divider. Will be between 0 and 2600 ohms.

$ Low-impedance output (few tens to few hundreds of ohms) from linear integrated circuit.

/ Special case, described on same line as pin-number listing.

NO SYMBOL. An input rather than an output. Device supplying signal to this point must operate between nominal levels of 0 and +5 V, and be capable of sinking 1.6 mA, dc, in the 0-V state.

Table 3-5
CONNECTOR AJ1 – TO 1522 OR HOUSTON INSTRUMENTS RECORDER

RECUR	AJ1-1	=	X-axis voltage to XY plotters. Voltage appears on this line only when the XY PLOT or REMOTE ADVANCE buttons are pushed. Otherwise, this line is at ground potential.
HEATH	AJ1-2		"SHIFT-TO-NEXT-CHANNEL" Command. Positive pulse lasting 0.25 μs or longer will cause the next channel to be displayed during the output phase of operation, provided the REMOTE ADVANCE button is pushed or REMOTE operation is established by grounding AJ2-24. (Compare to HASTE.)
GNDCH	AJ1-3	–	Chassis Ground. Makes connection to the metal case of the instrument.
GNDCH	AJ1-4	–	Chassis Ground. Makes connection to the metal case of the instrument.
RHINO	AJ1-5	/	Recognizes 1522 has advanced to new page, capacitor coupled, Z_{in} = 1500 Ω, approx. The photocell on the 1522 that "sees" the black stripe marking the start of a new recording chart causes the voltage on this line to go from +5 V to 0 V. The 1926 generates a motor stop pulse to end the paper motion of the 1522, and the 1926 makes a new measurement, replots the same data, or quits, depending on the MEASUREMENT MODE button.
RESIN	AJ1-6	/	Motor stop for 1522 paper drive, Z_{out} = 2200 Ω when voltage is +5, and about 100 Ω when voltage is 0. Voltage on this line is normally +5. When the voltage drops to 0, the 1522 paper transport motor stops. Motor stop signal is a pulse lasting approximately 50 μs (time not at all critical), going from +5 to 0 V in less than 1 μs and from 0 V back to 3% with a more-or-less long, sloppy exponential recovery.
GUEST	AJ1-7	*	This voltage goes to 0 at the moment display starts, and remains at 0 V until display ends. The voltage is +5 during non-display times. The voltage remains at 0 all through display, including the time of about 14.5 μs while the channel just displayed is being replaced with the value for the next channel. (Compare to PADDY, equivalent signal of opposite polarity.) "Displayed" refers to channels actually being displayed. For example, if an instrument is designed to use channels 14-43, but only channels 20-25 are set by the LOWEST BAND NUMBER and HIGHEST BAND NUMBER switches, then line GUEST is at 0 V only while the internal circuits are working with channels 20-25.
REACH	AJ1-8	(	"ADVANCE-TO-NEW-PAGE" Command for Houston Instrument and similar XY plotters. Just before a new set of data are to be plotted, the voltage on this line goes from 0 to +5 for approximately 1/2 s. This is a command to the Houston Instrument plotter to bring a new sheet of paper onto the platen, and the time delay of 1/2 s allows the paper movement to finish.
HASTE	AJ1-9		"SHIFT-TO-NEXT-CHANNEL" Command. (Compare to HEATH.) This input causes the next channel to be displayed during the output phase of operation, provided the REMOTE ADVANCE button is pushed or REMOTE operation is established by grounding AJ2-24. A pulse going from +5 V to 0 V and back to +5, lasting 0.25 μs or longer is required. If channel advance is desired from "downgoing" pulses of the type just described, they must be applied to AJ1-09, whereas "upgoing" pulses will work correctly only on AJ1-02. IMPORTANT: If AJ1-09 is used for channel advance with downgoing pulses, contact AJ1-02 ***must*** be connected to Signal Ground, AJ2-13.
MACAW	AJ1-10	+	***Each time*** a new channel is displayed, the voltage on this line rises from 0 to +5 V, if XY PLOT, PRINTER, or REMOTE ADVANCE buttons are pressed, or the equivalent of pressing these buttons is achieved by grounding lines RAGED, RACKS, or HEART on connector AJ2. During the time of approximately 14.5 μs necessary to change from one channel to the next, the voltage on this line drops back to 0.
GNDSG	AJ1-12	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
GNDSG	AJ1-13	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
RENEW	AJ1-14		When the 1926 is used with the General Radio Type 1522 Recorder, this point is brought to ground potential when the recorder is present and turned on. This enables the automatic advance to a new chart after a plot is completed.

Table 3-5 cont.

REFER	AJ1-15	$	Y Axis voltage to XY plotters. Voltage appears on this line only when the XY PLOT or REMOTE ADVANCE buttons are pushed. Otherwise, this line is at ground potential.
GNDCH	AJ1-16	–	Chassis Ground. Makes connection to the metal case of the instrument.
RHYME	AJ1-17		Recognizes photocell mark when 1522 chart paper has reached the end of one channel and causes the paper to stop. Voltage on this line is normally +5, and goes to 0 V at the moment the mark is "seen."
REPAY	AJ1-18	/	Motor-start signal for 1522 paper drive, Z_{out} = 2200 Ω when voltage is +5, and about 100 Ω when voltage is at 0. Normally at +5 V; drop to 0 V initiates start of paper motion.
PADDY	AJ1-19	*	This voltage goes to +5 at the moment display starts, and remains at +5 until display ends. The voltage is 0 during non-display times. The voltage remains at +5 all through display, including the time of about 14.5 μs while the channel just displayed is being replaced with the value for the next channel. (Compare to GUEST, equivalent signal of opposite polarity.) "Display" refers to channels actually being displayed. For example, if an instrument is designed to use channels 14-43, but only channels 20-25 are set by the LOWEST BAND NUMBER and HIGHEST BAND NUMBER switches, then line PADDY is at 5 V only while the internal circuits are working with channels 20-25.
RANCH	AJ1-20	(	Pen-control voltage. This signal operates only when enabled by pressing the XY PLOT or REMOTE ADVANCE buttons. This voltage goes to +5 at the moment display starts, and remains at +5 until display ends. The voltage remains at +5 all through display, including the time of about 14.5 μs while the channel just displayed is being replaced with the value for the next channel. Note similarity to signal PADDY at AJ1-19, except RANCH works only with XY PLOT and REMOTE ADVANCE.
PLS05	AJ1-21	–	Positive 5 V, dc. This is intended as a reference voltage, and comes from the same power supply that feeds the integrated circuits in the 1926. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the PLS05 pins on all other connectors, does not exceed 200 mA. This voltage will have many "spikes" of several tenths of a volt on it. Do not use it for anything that requires clean, well-filtered power.
MIN20	AJ1-22	–	Negative 20 V, dc. This is intended as a reference voltage. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the MIN20 pins on all other connectors, does not exceed 20 mA. This voltage must be kept free of transients, surges, hum, etc. Do not connect anything that will impair its status as clean power.
PLS20	AJ1-23	–	Positive 20 V, dc. This is intended as a reference voltage. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the PLS20 pins on all other connectors, does not exceed 20 mA. This voltage must be kept free of transients, surges, hum. etc. Do not connect anything that will impair its status as clean power.

Table 3-6
CONNECTOR AJ2 – PANEL CONTROLS

FRIAR	AJ2-1	Ground this point to "START." Reducing the potential at this terminal from +5 to 0 V (contact closure to Signal Ground or the electronic equivalent, such as through a saturated transistor switch) for 0.25 μs or longer causes a new measurement to begin.
GRAVY	AJ2-2	Ground this point to "STOP." Reducing the potential at this terminal from +5 to 0 V (contact closure to Signal Ground or the electronic equivalent, such as through a saturated transistor switch) for 0.25 μs or longer causes all activity in the 1926 to stop (except for jitter on the XY Plotter or CRO, if STOP occurs while an overloaded channel is displayed). Operation can be made to resume only by a new START command.
GLASS	AJ2-3	Ground for programming SINGLE type of MEASUREMENT MODE. Reduce the potential on this line from +5 to 0 V by contact closure to Signal Ground or the electronic equivalent, such as through a saturated transistor switch. The voltage must remain at ground potential during the entire sequence of integration and display. See note under GLARE.
GNDSG	AJ2-4	Signal ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
GLINT	AJ2-5	Ground for integration times of 1/8, 1/4, 1/2, and 1 second (note that, for 1/8, 1/4, and 1/2 second, another line must be grounded also). Reduce the potential on this line from +5 V to 0 V (contact closure to Signal Ground or the electronic equivalent, such as through a saturated transistor switch) and retain the potential at 0 V during the entire integration time, at least. Normally this point is left at ground potential as long as measurements are made of 1 s or less duration.
GLOAT	AJ2-6	Ground for 2-second integration time. Contact closure or equivalent to Signal Ground. The potential must remain at 0 for the entire integration time, at least. Normally this point is left at ground potential as long as measurements are made of 2-seconds duration.
GLOBE	AJ2-7	Ground for 4-second integration time. See remarks under GLOAT.
GLOOM	AJ2-8	Ground for 8-second integration time. See remarks under GLOAT.
GOING	AJ2-9	Ground for 16-second integration time. See remarks under GLOAT.
GORGE	AJ2-10	Ground for 32-second integration time. See remarks under GLOAT.
ERUPT	AJ2-11	External programming of LOWEST BAND NUMBER, value 4 in BCD. Contact closure or equivalent to Signal Ground. To make external programming of LOWEST BAND NUMBER or HIGHEST BAND NUMBER possible, front-panel switches must be set to 00. Normally the selected LOWEST BAND NUMBER and HIGHEST BAND NUMBER BCD addresses are left at ground potential as long as measurements are being made with the same starting and ending points for displayed bands. In any case, the selected LOWEST BAND NUMBER and HIGHEST BAND NUMBER programming voltages must remain at ground potential during the entire duration of any one output operation.
ERECT	AJ2-12	Ground to program LOWEST BAND NUMBER, value 8 in BCD. See notes under ERUPT.
ENVOY	AJ2-13	Ground to program LOWEST BAND NUMBER, value 40 in BCD. See notes under ERUPT.
FACET	AJ2-15	Ground to program HIGHEST BAND NUMBER, value 4 in BCD. See notes under ERUPT.
FABLE	AJ2-16	Ground to program HIGHEST BAND NUMBER, value 8 in BCD. See notes under ERUPT.
EXCEL	AJ2-17	Ground to program HIGHEST BAND NUMBER, value 40 in BCD. See notes under ERUPT.
RACES	AJ2-19	Ground this line to achieve external programming of OUTPUT DISPLAY, OSCILLOSCOPE, STORE-ERASE. Make contact closure or equivalent to Signal Ground. To make external programming of OUTPUT DISPLAY possible, the front-panel OUTPUT DISPLAY pushbuttons must all be released. Normally, line RACES is left at ground potential as long as you desire the STORE-ERASE mode, but, in any event, it must stay at ground potential during the entire duration of any one output operation.
RABID	AJ2-20	Ground this line for external programming of OUTPUT DISPLAY, OSCILLOSCOPE, STORE-NO ERASE. See general comments under RACES.
RAFTS	AJ2-21	Ground this line for external programming of OUTPUT DISPLAY, XY PLOT. Printer is simultaneously enabled, and oscilloscopes are put into store-no erase display mode. See general comments under RACES.
RAGED	AJ2-22	Ground this line for external programming of OUTPUT DISPLAY, PRINTER. Oscilloscopes are simultaneously put into store-no erase display mode. See general comments under RACES.

RACKS	AJ2-23		Ground this line for external programming of OUTPUT DISPLAY, PRINTER. Oscilloscopes are simultaneously put into store-no erase display mode. See general comments under RACES.
HEART	AJ2-24		Ground this line for external programming of REMOTE ADVANCE. Simultaneously enables XY PLOT, PRINTER, and CRO STORE-NO ERASE. See general comments under RACES. Note that fully-remote operation as enabled by bringing HEART to ground potential will also involve signals moving back and forth on lines HASTE, HEATH, LARGE, LOYAL, and LUCID, or some combination thereof.
HANDY	AJ2-26		Ground this point to "START." See FRAIR, AJ2-01. HANDY operates in identically the same way as far as considerations external to the 1926 are concerned.
FRESH	AJ2-27		Ground for MANUAL ADVANCE. Bringing this wire from +5 to 0 V potential for 0.25 μs or more will have the same effect as pushing the MANUAL ADVANCE button. BEWARE CONTACT BOUNCE if a device like a pushbutton is used. The normal MANUAL ADVANCE button drives elaborate anti-bounce circuits. These circuits are not available for commands entering the instrument from this connection point.
GLARE	AJ2-28		Ground for programming MULTIPLE type of MEASUREMENT MODE. Reduce the potential on this line from +5 to 0 V by contact closure to Signal Ground or the electronic equivalent, such as through a saturated transistor switch. The voltage must remain at ground potential continuously as long as MULTIPLE action is desired. NOTE: For SINGLE-HOLD, leave both GLASS and GLARE ungrounded.
ANNOY	AJ2-30		Ground for 1/8-second integration time. GLINT must be grounded also. See general comments under GLINT.
ANVIL	AJ2-31		Ground for 1/4-second integration time. GLINT must be grounded also. See general comments under GLINT.
ANTIC	AJ2-32		Ground for 1/2-second integration time. GLINT must be grounded also. See general comments under GLINT.
GNDSG	AJ2-35		Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
EVADE	AJ2-36		Ground to program LOWEST BAND NUMBER, value 1 in BCD. See notes under ERUPT.
ESSAY	AJ2-37		Ground to program LOWEST BAND NUMBER, value 2 in BCD. See notes under ERUPT.
EQUIP	AJ2-38		Ground to program LOWEST BAND NUMBER, value 10 in BCD. See notes under ERUPT.
EPOCH	AH2-39		Ground to program LOWEST BAND NUMBER, value 20 in BCD. See notes under ERUPT.
FAITH	AJ2-40		Ground to program HIGHEST BAND NUMBER, value 1 in BCD. See notes under ERUPT.
FAINT	AJ2-41		Ground to program HIGHEST BAND NUMBER, value 2 in BCD. See notes under ERUPT.
EXILE	AJ2-42		Ground to program HIGHEST BAND NUMBER, value 10 in BCD. See notes under ERUPT.
EXALT	AJ2-43		Ground to program HIGHEST BAND NUMBER, value 20 in BCD. See notes under ERUPT.
RELIC	AJ2-44		Ground to "PAUSE." Reducing potential on this line from +5 to 0 V by contact closure to Signal Ground or equivalent method such as a saturated transistor switch stops operations of the 1926, both in the integrate and display modes. When the grounded condition is terminated, operation resumes just where it was interrupted.
MIN20	AJ2-46	–	Negative 20 V, dc. This is intended as a reference voltage. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the MIN20 pins on all other connectors, does not exceed 20 mA. This voltage must be kept free of transients, surges, hum, etc. Do not connect anything that will impair its status as clean power.
PLS20	AJ2-47	–	Positive 20 V, dc. This is intended as a reference voltage. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the PLS20 pins on all other connectors, does not exceed 20 mA. This voltage must be kept free of transients, surges, hum, etc. Do not connect anything that will impair its status as clean power.
PLS05	AJ2-48	–	Positive 5 V, dc. This is intended as a reference voltage, and comes from the same power supply that feeds the integrated circuits in the 1926. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the PLS05 pins on all other connectors, does not exceed 200 mA. This voltage will have many "spikes" of several tenths of a volt on it. Do not use it for anything that requires clean, well-filtered power.
DITCH	AH2-49	*	"Integration" indicator. This line is at +5 V when integration is in progress, and at 0 V when the instrument is in the output (display) mode.
GNDCH	AJ2-50	–	Chassis Ground. Makes connection to the metal case of the instrument.

Table 3-7
CONNECTOR AJ3 FOR USE WITH GENERAL RADIO TYPE 1566.

FRAUD	AJ3-1		Ground to use 8 microphones. Notes: When the General Radio Type 1566 is in use, grounding this line causes the 1926 to pause after each 1/8th portion of the integration samples (1/2 for FRILL, 1/4 for FRIED, 1/16th for FRANK). Simultaneously, the 1926 sends a command to the 1566 to turn on the next microphone in the set of 8 (or 2, 4, 16 for FRILL, FRIED, FRANK).
FRANK	AJ3-2		Ground to use 16 microphones. See notes under FRAUD.
GNDSG	AJ3-3	–	Signal ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
MONEY	AJ3-4	+	Command to advance to next microphone. This is the simultaneous command mentioned in the notes under FRAUD. The signal consists of a transition from +5 V to 0 V (+15 to 0 if Board W is of the 15-V type). The 0-voltage condition continues until the 1566 sends back a signal indicating it has advanced to the next microphone. During the time of waiting for the microphone switching, all activity in the 1926 is stopped.
DITCH	AJ3-5	*	"Integration" indicator. This line is at +5 V when integration is in progress, and at 0 V when the instrument is in the output mode.
DIRGE	AJ3-6	*	"Display" indicator. This line is at +5 V when the output mode is in progress, and at 0 V when integration is in progress. Note: DIRGE and DITCH are the exact opposites of each other.
PADDY	AJ3-7	*	This voltage goes to +5 at the moment display starts, and remains at +5 V until display ends. The voltage is 0 during non-display times. The voltage remains at +5 all through display, including the time of about 14.5 μs while the channel just displayed is being replaced with the value for the next channel. "Display" refers to channels actually being displayed. For example, if an instrument is designed to use channels 14-43, but only channels 20-25 are set by the LOWEST BAND NUMBER and HIGHEST BAND NUMBER switches, then line PADDY is at 5 V only while the internal circuits are working with channels 20-25.
PLS05	AJ3-8	–	Positive 5 V, dc. This is intended as a reference voltage, and comes from the same power supply that feeds the integrated circuits in the 1926. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the PLS05 pins on all other connectors, does not exceed 200 mA. This voltage will have many "spikes" of several tenths of a volt on it. Do not use it for anything that requires clean, well-filtered power.
DOLLY	AJ3-9		Ground to program MAXIMUM BAND LEVEL dB, value 4 BCD. Notes applicable to DITTY, DODGE, DOLLY, DONOR, DOUGH, DRAFT, DRAKE, and DRAMA: Grounding these lines causes the selected BCD values to be programmed as the MAXIMUM BAND LEVEL dB. "Grounding" refers to bringing the potential on these lines to 0 V, either by contact closure to Signal Ground, or an electronic equivalent, such as a saturated transistor switch. Normally, the selected lines are left continuously at ground potential until you wish to use a different value of MAXIMUM BAND LEVEL dB. In any case, the selected lines must remain at ground potential at least while the desired channels are being displayed. To make programming of the MAXIMUM BAND LEVEL dB possible, the front-panel MAXIMUM BAND LEVEL dB switches must be set to 60.
DONOR	AJ3-10		Ground to program MAXIMUM BAND LEVEL dB, value 8 BCD. See notes under DOLLY.
DRAKE	AJ3-11		Ground to program MAXIMUM BAND LEVEL dB, value 40 BCD. See notes under DOLLY.
DRAMA	AJ3-12		Ground to program MAXIMUM BAND LEVEL dB, value 80 BCD. See notes under DOLLY.
FRILL	AJ3-13		Ground to use 2 microphones. See notes under FRAUD.
FRIED	AJ3-14		Ground to use 4 microphones. See notes under FRAUD.
GNDCH	AJ3-15	–	Chassis Ground. Makes connection to the metal case of the instrument.
HABIT	AJ3-16		"Resume" command after changing microphones. This line is the reply-back point for a signal from the 1566 that the next microphone in sequence has been turned on and integration may resume in the 1926. The signal must be a pulse going from +5 V to 0 and back to +5, lasting at least 0.25 μs, but not to exceed a few ms. Exact shape not critical.

Table 3-7 cont.

FRIAR	AJ3-17	Ground this point to "START." Reducing the potential at this terminal from +5 to 0 V (contact closure to Signal Ground or the electronic equivalent, such as through a saturated transistor switch) for 0.25 μs or longer causes a new measurement to begin.
GRAVY	AJ3-18	Ground this point to "STOP." Reducing the potential at this terminal from +5 to 0 V (contact closure to Signal Ground or the electronic equivalent, such as through a saturated transistor switch) for 0.25 μs or longer causes all activity in the 1926 to stop (except for jitter on the XY plotter or CRO if STOP occurs shile an overloaded channel is displayed). Operation can be made to resume only by a new START command.
MIN20	AJ3-19	– Negative 20 V, dc. This is intended as a reference voltage. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the MIN20 pins on all other connectors, does not exceed 20 mA. This voltage must be kept free of transients, surges, hum, etc. Do not connect anything that will impair its status as clean power.
PLS20	AJ3-20	– Positive 20 V, dc. This is intended as a reference voltage. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the PLS20 pins on all other connectors, does not exceed 20 mA. This voltage must be kept free of transients, surges, hum, etc. Do not connect anything that will impair its status as clean power.
DITTY	AJ3-21	Ground to program MAXIMUM BAND LEVEL dB, value 1 BCD. See notes under DOLLY.
DODGE	AJ3-22	Ground to program MAXIMUM BAND LEVEL dB, value 2 BCD. See notes under DOLLY.
DOUGH	AJ3-23	Ground to program MAXIMUM BAND LEVEL dB, value 10 BCD. See notes under DOLLY.
DRAFT	AJ3-24	Ground to program MAXIMUM BAND LEVEL dB, value 20 BCD. See notes under DOLLY.

Table 3-8
CONNECTOR AJ4—DIGITAL OUTPUT

			Note 1: Lines so designated are at +5 V when in the "1," "true," "on," "yes," "addressed," etc., state. They are at 0 V otherwise. These lines designate the band number being displayed and the value of the answer for the corresponding band number, all in BCD, except fractions (1/4, 1/2) of a dB, which are in binary. If board W is of the 15-V type, "+5 V" becomes "+15 V."
MEDAL	AJ4-1	+	dB out, 1/4 dB, binary. Note 1.
GNDSG	AJ4-2	—	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
MARRY	AJ4-3	+	dB out, 1/2 dB, binary. Note 1.
MEDAL	AJ4-4	+	dB out, 1/4 dB, binary. Note 1.
MIDST	AJ4-5	+	dB out, 1 dB, BCD. Note 1.
MOURN	AJ4-6	+	dB out, 2 dB, BCD. Note 1.
MARCH	AJ4-7	+	dB out, 10 dB, BCD. Note 1.
MEATY	AJ4-8	+	dB out, 20 dB, BCD. Note 1.
MERIT	AJ4-9	+	dB out, 100 dB, BCD. Note 1.
GNDSG	AJ4-10	—	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
RECAP	AJ4-11	*	Signal indicating a band is being displayed; +5 V during the display of each individual band, going to 0 V during the 14.5 μs time intervals while the band just displayed is replaced by the next band to be displayed.
MOLAR	AJ4-12	+	"Integration" indicator. This line is at +5 V (+15 if Board W is of the 15-volt type) when integration is in progress, and at 0 V when the instrument is in the output mode.
MIRTH	AJ4-13	+	Band number output, 1, BCD. Note 1.
MIXED	AJ4-14	+	Band number output, 2, BCD. Note 1.
MOIST	AJ4-15	+	Band number output, 10, BCD. Note 1.
MISER	AJ4-16	+	Band number output, 20, BCD. Note 1.
DIRGE	AJ4-17	*	"Display" indicator. This line is at +5 V when the output mode is in progress, and at 0 V when integration is in progress.
LUCID	AJ4-18		Computer report-back "Finished Absorbing Data." If computers are used with the 1926, lines MAJOR and MAGIC (AJ4-42 and AJ4-44) give "busy" and "data ready" signals to tell the computer when it should not or should (respectively) read-in answers. The "data ready" signal should be thought of as a flag that is raised when an answer is to be read. This flag must be dropped as soon as the computer has read the answer lest the same answer be read again and again. Line LUCID pprovides for this resetting of the flag. The signal on LUCID must be a transition from +5 V to 0 V. Duration is not critical: 0.25 to 10 μs is OK, after which LUCID must return to +5
HASTE	AJ4-19		"SHIFT-TO-NEXT-CHANNEL" command. (Compare to HEATH.) This input causes the next channel to be displayed during the output phase of operation, provided the REMOTE ADVANCE button is pushed or REMOTE operation is established by grounding AJ4-20. A pulse going from +5 V to 0 V and back to +5, lasting 0.25 μs or longer is required. If channel advance is desired from "downgoing" pulses of the type just described, they must be applied to AJ4-19, whereas "upgoing" pulses will work correctly only on AJ4-45. IMPORTANT: If AJ4-19 is used for channel advance with "downgoing" pulses, contact AJ4-45 must be connected to Signal Ground, AJ4-48.
HEART	AJ4-20		Ground this line for external programming of REMOTE ADVANCE. Simultaneously enables XY PLOT, PRINTER, and CRO STORE-NO ERASE. Note that fully-remote operation as enabled by bringing HEART to ground potential will also involve signals moving back and forth on lines HASTE, HEATH, LARGE, LOYAL, and LUCID or some combination thereof. Ground to Signal Ground by contact closure or the electronic equivalent, such as a saturated transistor switch.
PLS20	AJ4-21	—	Positive 20 V, dc. This is intended as a reference voltage. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the PLS20 pins on all other connectors, does not exceed 20 mA. This voltage must be kept free of transients, surges, hum, etc. Do not connect anything that will impair its status as clean power.
PLS05	AJ4-22	—	Positive 5 V, dc. This is intended as a reference voltage, and comes from the same power supply that feeds the integrated circuits in the 1926. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the PLS05 pins on all other connectors, does not exceed 200 mA. This voltage will have many "spikes" of several tenths of a volt on it. Do not use it for anything that requires clean, well-filtered power.

Table 3-8 cont.

MIN20	AJ4-23	–	Negative 20 V, dc. This is intended as a reference voltage. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the MIN20 pins on all other connectors, does not exceed 20 mA. This voltage must be kept free of transients, surges, hum, etc. Do not connect anything that will impair its status as clean power.
MADAM	AJ4-24	+	***Each time*** a new channel is displayed, the voltage on this line drops from +5 V to 0 V, if XY PLOT, PRINTER, or REMOTE ADVANCE buttons are pressed, or the equivalent of pressing these buttons is achieved by grounding lines RAGED, RACKS, or HEART on connector AJ2. During the time of approximately 14.5μs necessary to change from one channel to the next, the voltage on this line rises to +5.
MEDAL	AJ4-26	+	dB out, 1/4 dB, binary. Note 1.
GNDSG	AJ4-27	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
MARRY	AJ4-28	+	dB out, 1/2 dB, binary. Note 1.
GNDSG	AJ4-29	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
MOUNT	AJ4-30	+	dB out, 4 dB, BCD. Note 1.
MINCE	AJ4-31	+	dB out, 8 dB, BCD. Note 1.
MEDIA	AJ4-32	+	dB out, 40 dB, BCD. Note 1.
MERGE	AJ4-33	+	dB out, 80 dB, BCD. Note 1.
GNDSG	AJ4-34	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
MERCY	AJ4-35	+	dB out, 800 dB, BCD. Note 1.
REBEL	AJ4-36	*	***Each time*** a new channel is displayed, the voltage on this line drops from +5 V to 0 V, and remains at 0 V until the display of that channel ends. The voltage rises to +5 again during the 14.5 μs necessary to change from one channel to the next.
MODEL	AJ4-38	+	Band number output, 4, BCD. Note 1.
MINOR	AJ4-39	+	Band number output, 8, BCD. Note 1.
MISTY	AJ4-40	+	Band number output, 40, BCD. Note 1.
GNDSG	AJ4-41	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
MAJOR	AJ4-42	+	"BUSY" signal to computers. While the 1926 is processing data or changing from one output band to the next, this line is at +5 V (+15, if Board W is of the 15-V type). Positive voltage is meant to be a warning to the computer not to read-in data at this time.
MACAW	AJ4-43	+	***Each time*** a new channel is displayed, the voltage on this line rises from 0 to +5 V, if XY PLOT, PRINTER, or REMOTE ADVANCE buttons are pressed, or the equivalent of pressing these buttons is achieved by grounding lines RAGED, RACKS, or HEART on connector AJ2. During the time of approximately 14.5 μs, necessary to change from one channel to the next, the voltage on this line drops to 0.
MAGIC	AJ4-44	+	"DATA READY" signal to computer. When an answer is waiting to be read into the computer, this voltage changes from 0 to +5 (+15 if Board W is the 15-V type). This voltage acts as a flag, which must be reset by momentarily bringing the potential on line LUCID to 0 V. (see LUCID, AJ4-18).
HEATH	AJ4-45		"SHIFT-TO-NEXT-CHANNEL" Command. Positive pulse lasting 0.25 μs or longer will cause the next channel to be displayed during the output phase of operation, provided the REMOTE ADVANCE button is pushed or REMOTE operation is established by grounding AJ2-24. (Compare to HASTE.)
LARGE	AJ4-46	*	"BUSY" signal to computers. While the 1926 is processing data or changing from one output band to the next, this line is at +5 V. Positive voltage is meant to be a warning to the computer not to read-in data at this time. Line LARGE is equivalent to line MAJOR (q.v.), except that MAJOR is buffered by an output amplifier, and lin LARGE comes directly from the etched board holding the control circuits. LARGE has a lower output impedance, and is more vulnerable to damage from externally-injected transients than line MAGIC.
LOYAL	AJ4-47	*	"DATA READY" signal to computer. When an answer is waiting to be read into the computer, this voltage changes from 0 to +5 V. This voltage acts as a flag, which must be reset by momentarily bringing the potential on line LUCID to 0 V. (See LUCID, AJ4-18). Line LOYAL is equivalent to line MAGIC (q.v.), except that MAGIC is buffered by an output amplifier, and line LOYAL comes directly from the etched board holding the control circuits. LOYAL has a lower output impedance, and is more vulnerable to damage from externally-injected transients than line MAGIC.
GNDSG	AJ4-48	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
PAVED	AJ4-49	–	Reference voltage equal to the supply voltage of the output buffer amplifiers on Board W. This voltage will be either +5 or +15 V, depending on whether Board W is of the 5-V or 15-V type. This is not intended as a source of power. No more than a few milliamperes should be drawn from this terminal.
GNDCH	AJ4-50	–	Chassis Ground. Makes connection to the metal case of the instrument.

Table 3-9
CONNECTOR AJ7—TO OSCILLOSCOPE (1921-P1)

LUCKY	AJ7-1	=	X-axis voltage. This voltage is always present, regardless of the settings of the OUTPUT DISPLAY buttons on the front panel.
GNDSG	AJ7-2	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
GNDCH	AJ7-3	–	Chassis Ground. Makes connection to the metal case of the instrument.
GNDCH	AJ7-4	–	Chassis Ground. Makes connection to the metal case of the instrument.
RALLY	AJ7-5	/	This is +15 V when storage is possible, 0 V when storage is prevented. Z_{out} = about 12 kΩ in the +15-V state, and about 100 Ω in the 0-V state. This line is always at +15 V, except when the OUTPUT DISPLAY, OSCILLOSCOPE, NON-STORE button is pushed. Note: there is no 5-V option.
GUEST	AJ7-6	*	This voltage goes to 0 at the moment display starts, and remains at 0 V until display ends. The voltage is at +5 during non-display times. The voltage remains at 0 all through display, including the time of about 14.5 μs while the channel just displayed is being replaced with the value for the next channel. (Compare to PADDY, equivalent signal of opposite polarity.) "Display" refers to channels actually being displayed. For example, if an instrument is designed to use channels 14-43, but only channels 20-25 are set by the LOWEST BAND NUMBER and HIGHEST BAND NUMBER switches, then line GUEST is at 0 V only while the internal circuits are working with channels 20-25.
MIN20	AJ7-7	–	Negative 20 V, dc. This is intended as a reference voltage. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the MIN20 pins on all other connectors, does not exceed 20 mA. This voltage must be kept free of transients, surges, hum, etc. Do not connect anything that will impair its status as clean power.
GNDSG	AJ7-8	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
GNDSG	AJ7-19	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
GNDSG	AJ7-20	–	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
MOOSE	AJ4-21	$	Y-axis voltage. This voltage is always present, regardless of the settings of the OUTPUT DISPLAY buttons on the front panel.
GNDCH	AJ7-22	–	Chassis Ground. Makes connection to the metal case of the instrument.
RAINY	AJ7-23	/	Pulse to erase the stored trace on the CRO. This potential is normally +15 V (there is no 5-V option), and goes to 0 V for approximately 1/2 s to erase a stored image. Output impedance approximately 12 kΩ in the 15-V state and 100 Ω in the 0-V state.
PADDY	AJ7-24	*	Z-axis control voltage. The +5 V causes the trace to appear. This voltage goes to +5 at the moment display starts, and remains at +5 V until display ends. The voltage is 0 during non-display times. The voltage remains at +5 all through display, including the time of about 14.5 μs while the channel just displayed is being replaced with the value for the next channel. "Display" refers to channels actually being displayed. For example, if an instrument is designed to use channels 14-43, but only channels 20-25 are set by the LOWEST BAND NUMBER and HIGHEST BAND NUMBER switches, then line PADDY is at +5 V only while the internal circuits are working with channels 20-25.
PLS20	AJ7-25	–	Positive 20 V, dc. This is intended as a reference voltage. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the PLS20 pins on all other connectors, does not exceed 20 mA. This voltage must be kept free of transients, surges, hum, etc. Do not connect anything that will impair its status as clean power.
PLS05	AJ7-26	–	Positive 5 V, dc. This is intended as a reference voltage, and comes from the same power supply that feeds the integrated circuits in the 1926. A moderate amount of current may be drawn. Be sure the current drawn from this pin, plus currents from the PLS05 pins on all other connectors, does not exceed 200 mA. This voltage will have many "spikes" of several tenths of a volt on it. Do not use it for anything that requires clean, well-filtered power.

Table 3-10
CONNECTORS FOR X-Y RECORDER

RECUR	AJ10, Center	X axis voltage to XY plotters. Voltage appears on this line only when the XY PLOT or REMOTE ADVANCE buttons are pushed. Otherwise, this line is at ground potential.
GNDSG	AJ10, Shell	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.
REFER	AJ11, Center	Y axis voltage to XY plotters. Voltage appears on this line only when the XY PLOT or REMOTE ADVANCE buttons are pushed. Otherwise, this line is at ground potential.
GNDSG	AJ11, Shell	Signal Ground. A ground to the internal circuits of the instrument, as distinguished from the metal case.

Table 3-11
CONNECTOR AJ6 CHANNEL INPUTS (TO 1925)

AJ6-01	Channel 1 input.	AJ6-17	Channel 17 input.
AJ6-02	Channel 2 input.	AJ6-18	Channel 18 input.
AJ6-03	Channel 3 input.	AJ6-19	Channel 19 input.
AJ6-04	Channel 4 input.	AJ6-20	Channel 20 input.
AJ6-05	Channel 5 input.	AJ6-21	Channel 21 input.
AJ6-06	Channel 6 input.	AJ6-22	Channel 22 input.
AJ6-07	Channel 7 input.	AJ6-23	Channel 23 input.
AJ6-08	Channel 8 input.	AJ6-24	Channel 24 input.
AJ6-09	Channel 9 input.	AJ6-25	Channel 25 input.
AJ6-10	Channel 10 input.	AJ6-26	Channel 26 input.
AJ6-11	Channel 11 input.	AJ6-27	Channel 27 input.
AJ6-12	Channel 12 input.	AJ6-28	Channel 28 input.
AJ6-13	Channel 13 input.	AJ6-29	Channel 29 input.
AJ6-14	Channel 14 input.	AJ6-30	Channel 30 input.
AJ6-15	Channel 15 input.	AJ6-31	Signal ground.
AJ6-16	Channel 16 input.	AJ6-36	Chassis ground.

Table 3-12
CONNECTOR AJ5 CHANNEL INPUTS (TO AUXILIARY 1925)

AJ5-01	Channel 16 input.	AJ5-17	Channel 32 Input.
AJ5-02	Channel 17 input.	AJ5-18	Channel 33 input.
AJ5-03	Channel 18 input.	AJ5-19	Channel 34 input.
AJ5-04	Channel 19 input.	AJ5-20	Channel 35 input.
AJ5-05	Channel 20 input.	AJ5-21	Channel 36 input.
AJ5-06	Channel 21 input.	AJ5-22	Channel 37 input.
AJ5-07	Channel 22 input.	AJ5-23	Channel 38 input.
AJ5-08	Channel 23 input.	AJ5-24	Channel 39 input.
AJ5-09	Channel 24 input.	AJ5-25	Channel 40 input.
AJ5-10	Channel 25 input.	AJ5-26	Channel 41 input.
AJ5-11	Channel 26 input.	AJ5-27	Channel 42 input.
AJ5-12	Channel 27 input.	AJ5-28	Channel 43 input.
AJ5-13	Channel 28 input.	AJ5-29	Channel 44 input.
AJ5-14	Channel 29 input.	AJ5-30	Channel 45 input.
AJ5-15	Channel 30 input.	AJ5-31	Signal ground.
AJ5-16	Channel 31 input.	AJ5-36	Chassis ground.

3.5 USE OF ACCESSORY INSTRUMENTS.

3.5.1 Input Devices.

Preamplifier, GR Type 1560-P40

The Type 1560-P40 Preamplifier is a small, low-noise, high-input-impedance preamplifier designed for use between the transducer and a measuring instrument. It can be used to increase the signal level from the transducer without adding noise, and to deliver the signal to the measuring instrument over a long cable.

The conventional use of the Preamplifier places it at or near the transducer so that, with its low-output impedance, it can drive a long cable with no loss in signal level. Used in this fashion, the 1560-P40 can be used to drive cables up to 1 mile in length with unity gain and up to 1/2 mile in length with ten-to-one increase in signal level.

In some instances, as in vibration measurements, it has become common practice to connect the accelerometer to the input of a preamplifier through a long cable, so that the preamplifier is located at or near the indicating or recording system. In these cases, "charge" amplifiers are often used, which compensate for the capacitance by using a negative-feedback network and effectively maintain the open-circuit output of the transducer at the end of the cable. These charge amplifiers are convenient because one can set the appropriate gain for direct readout without worrying about cable loss. These amplifiers do suffer, however, from relatively high internal noise levels and limited dynamic range. Often, a lower level and wider dynamic range can be achieved by using a 1560-P40 Preamplifier and correcting for the cable loss.

Output connection from the Preamplifier is made through a 3-terminal, shielded connector.

Cables are available from GR in different lengths, to connect the OUTPUT to the 3-terminal microphone connector at the INPUT of the 1925 Multifilter. Preamplifier and Adaptor Set, P/N 1560-9510, includes the Preamplifier, a 4-ft cable, and three adaptors to connect the Preamplifier INPUT connector to 3-terminal microphone connectors, to GR874 connectors, and to the cartridge of the GR 1560-P3 Microphone.

Preamplifier and Microphone Set, P/N 1560-9520, includes the Preamplifier, a 25-ft cable, a 4-ft cable, a microphone cartridge, and a tripod to hold the Preamplifier and microphone.

Also available from GR is a 100-ft Extension Cable, P/N 1560-9977. Like the cables noted above, it is fitted with microphone jack and plug, to connect between the Preamplifier and the Multifilter.

The three above-mentioned cables have an extra conductor to carry the necessary dc power to the Preamplifier. Power is furnished by the 1925 Multifilter, through terminal 2 of the connectors.

Tape Recorder, GR Type 1525 Data Recorder.

Tailored specifically for acoustic-noise measurements, the GR Type 1525 Data Recorder is both a sound-level meter and audio tape recorder. With it one can make on-location measurements and calibrated recordings for unhurried and detailed laboratory analysis later, or make a permanent record of once-only events. The 1525 permits recording with a flat frequency-response characteristic, recommended for recording noise. This characteristic is not available with speech and music recorders. Dual channels, simultaneous playback and recording, two-speed drive, and accessory tape-loop guides add versatility.

The 1525 Recorder produces a maximum output level of about 1 V to drive the analyzer. A calibration signal stored on the tape allows the calibration factor, lost in the recording process, to be restored by the 1921. The MAXIMUM LEVEL dB controls are used to make the Analyzer read in dB, with the reference level of the original signal.

The 1525 Data Recorder is supplied as a standard production unit by General Radio. Other tape recorders with good dynamic range, frequency range, and stable characteristics may be suitable for use with the 1921.

A recording of a calibration signal should be made before recording the sound to be analyzed (refer to Section 3 of the Type 1525 Instruction Manual). With the recording completed, use the following procedure to analyze the sound:

a. Connect a shielded cable from the PLAYBACK OUTPUT CH-1 to either INPUT connector on the 1925 Multifilter. The OUTPUT connector on the 1525 is a telephone jack that accepts a standard 2-contact telephone plug, such as Switchcraft No. 440, or equivalent.

b. Turn on the power to the instruments.

c. Set the attenuators on the 1925 to 0 dB.

d. Set the controls on the 1926 as follows:

PANEL DISPLAY button . . . . . .in
INTEGRATION TIME . . . . . 1/2 second
MODE . . . . . MULTIPLE
OUTPUT DISPLAY . . . . . XY PLOT
DISPLAY RATE . . . . . 2 BANDS PER SECOND

Set the LOWEST and HIGHEST BAND NUMBER controls to the frequency of the calibration signal on the tape.

e. With the calibration signal being played back and on-scale meter indication on the 1525, set the MAXIMUM BAND LEVEL dB control to the ***full-scale*** value of the 1525 (sum of attenuator setting when the calibration signal was recorded plus full-scale meter reading of 10 dB).

f. Push the START button on the 1926.

g. Adjust the CAL control (thumb set) on the 1925 so that the Nixie readout on the 1926 reads the known level of the calibration signal.

h. Stop the tape playback.

i. Set the LOWEST and HIGHEST BAND NUMBER controls on the 1926 to give a span that covers the frequency range of interest.

j. Set the MAXIMUM BAND LEVEL dB control to the full-scale value of the 1525 setting when the sound to be analyzed was recorded (attenuator reading plus 10 dB).

k. Start the playback of the sound. The 1926 should now read directly in dB re 20 $\mu N/m^2$.

Calibration with a Sound-Level Meter.

A sound-level meter, such as the GR 1561, 1551, or 1565, in combination with a sound-level calibrator such as the GR 1562, can be used to calibrate the 1921. The procedure is as follows:

a. Place the calibrator on the microphone of the sound-level meter and connect the output from the meter to either input of the 1925 (refer to the instruction manuals for the instruments being used). Turn on the power to the instruments.

b. Set the attenuators on the sound-level meter so that the output from the calibrator produces an on-scale indication of the meter.

c. Set the attenuators on the 1925 to 0 dB.

d. Set the controls on the 1926 as follows.

PANEL DISPLAY button . . . . . .in
INTEGRATION TIME . . . . . .1/2 SECOND
MODE . . . . . MULTIPLE
OUTPUT DISPLAY . . . . . XY PLOT
DISPLAY RATE . . . . . .2 BANDS PER SECOND

Set the LOWEST and HIGHEST BAND NUMBER controls to the frequency of the calibrator.

Set the MAXIMUM BAND LEVEL dB control to the *full-scale* reading on the sound-level meter (sum of attenuator setting plus the 10-dB full-scale meter reading).

e. Push the START button on the 1926.

f. Adjust the CAL control (thumb set) on the 1925 so that the Nixie readout on the 1926 reads the known level of the calibrator signal (114 dB, with the 1562 Calibrator).

g. Remove the calibrator.

h. Set LOWEST and HIGHEST BAND NUMBER controls to give a span that covers the frequency range of interest.

i. Adjust the attenuator on the sound-level meter for an on-scale reading.

j. Adjust the MAXIMUM BAND LEVEL dB control to indicate the attenuator setting of the sound-level meter plus 10 dB (full-scale on the sound-level meter).

All readings of the 1926 will now be in dB re 20 $\mu N/m^2$.

3.5.2 Output Display Devices.

Oscilloscope, Type 1921-P1 Storage Display Unit.

NOTE

Separate instructions for the use of a Type 1921-P1 Storage Display Unit are included in this manual

a. Connect the cable assembly (P/N 1921-0210, supplied) from connector AJ7 on the 1926 to the REMOTE PROGRAM socket on the rear panel of the 1921-P1, as shown in Figure 2-3.

b. Connect the captive 3-terminal power cable on the 1921-P1 to the SWITCHED POWER connector on the rear panel of the 1926.

Three operating modes are provided for oscilloscope use and are: STORE-ERASE, STORE-NO ERASE, and NON STORE. Their functions are self explanatory and follow the designations with regard to STORE for storage oscilloscope and ERASE for erasure of a storage-oscilloscope pattern. Display rate is fixed at 1 ms per channel for oscilloscope display. Retrace time of the X-axis output is 0.5 ms.

A storage command appears as a 15-V level at the oscilloscope output connector (AJ7). Erase command is a 15-V pulse of 0.5-s duration, and occurs at the start of the output phase. Refer to paragraph 3.4.7 for a discussion of the remote control functions.

Type 1522 DC Recorder

The Type 1522 DC Recorder is a remote-programmable, high-speed, servo-type recorder. Although usable as a general-purpose dc recorder, its real advantages lie in its use for systems and remote-programming applications. It is ideally suited for use with the 1921, for automatic plotting of audio- and vibration-frequency spectra. The two instruments work together, each giving the necessary commands to the other, making a completely automated system. The sequence of operations is as follows:

a. When the START button is pushed, the 1921 measures.

b. When the measuring has been completed, the 1921 puts into storage the data for the first band.

c. The recorder pen moves up to the level of the first band and settles, on command from the 1921. This inhibits the chart drive for 100 ms. The pen then plots the level in the first band.

d. When the chart reaches the next assigned band, a photo-cell detection system is triggered by a black line on the chart paper and stops the 1522, which then commands the 1921 to display the next band.

e. With the next band displayed, the pen responds again, and, 100 ms later, the chart starts to display the level in the second band.

f. This process continues until all bands have been plotted, at which time the 1522 pen lifts and automatically indexes to the beginning of the next chart. It then waits for a new command from the START button on the 1921.

NOTE

This entire process takes only about 9 s for a 30-band 1921 with a 1-s integration time.

The procedure for use of the 1522 with the 1921 is given below. The Type 1522-P1 Preamplifier must be in place in the Recorder (refer to the Instruction Manual for the 1522 DC Recorder).

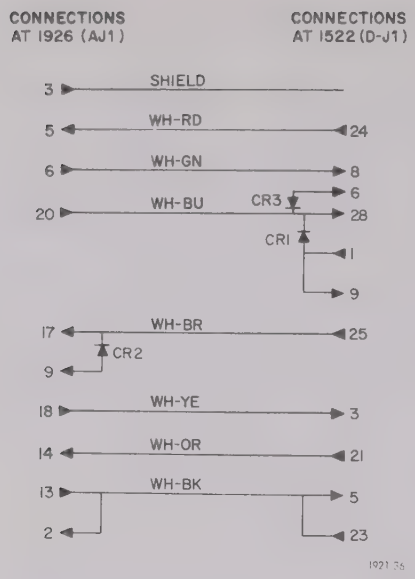


Figure 3-7. Pin connections for cable 1522-0320 between socket AJ1 on 1926 and socket D-J1 on 1522.

a. Set the LINE FREQUENCY slide switch on the 1522 to the frequency of the line power to be used. Be sure the line-voltage slide switches on all three instruments are set to the voltage of the line power.

b. Connect the line power to the 1925 power connector; use the 3-wire power cord, P/N 4200-9622, supplied with the 1921.

c. Connect the similar 3-wire power cord, P/N 4200-9622, supplied with the 1522, from the SWITCHED POWER socket on the 1926 to the power input connector on the 1522. The POWER switch on the 1925 will now control the power to each instrument in the system.

d. Cable Set P/N 1926-9670 consists of one cable, P/N 0776-9703, with a BNC plug on each end, and one cable, P/N 1522-0320, which has a 36-pin male plug (Amphenol 57-30360) on one end and a 24-pin male plug (Amphenol 57-30240) on the other. Connect the first cable from ANALOG LEVEL Y on the 1926 to DC INPUT on the 1522 and the second cable from AJ1 (TO 1522) on the 1926 to INPUT D-J1 on the 1522. All are rear-panel connections. The pin connections for the latter cable are given in Figure 3-7.

e. Connections between the 1925 and the 1926 should be as given in paragraph 2.6. Connect the signal to be analyzed to either INPUT connector on the 1925.

f. On the rear panel of the 1522, set the SYNC slide switch at INT and the LOGIC REFERENCE slide switch to OPEN.

g. Insert the selected chart paper in the 1522. Follow the procedure given in the Instruction Manual for the Recorder. Table 3-13 gives the specifications for each of eleven different papers that are available from GR, for use with the 1921. Each roll is 140 ft long, with a scale factor of 25 dB/decade. The inch-ruled papers have 2.08-in./decade abscissas; the centimeter-ruled papers have 5-cm/decade abscissas. Bands are ANSI-preferred 1/3-octave.

System Calibration

a. Set the controls on the 1522-P1 Preamplifier as follows:

VOLTAGE OR CURRENT . . . . . .0.2 V/IN.
INPUT POLARITY . . . . . - (minus)
Strap open

b. Set the controls on the 1522 as follows:

CHART SPEED . . . . . .0.5 SEC PER IN.
WRITING SPEED . . . . . 20 IN PER SEC
ZERO ADJUST . . . . . cw, initially
SCAN . . . . . SLOW
Chart direction . . . . . .STOP
PEN . . . . . UP

c. Set the controls on the 1926 as follows:

LOWEST BAND NUMBER . . . . . .full-scale calibrate channel
HIGHEST BAND NUMBER . . . .bottom-scale calibrate channel

(Refer to paragraph 3.3.2.)

MAXIMUM BAND LEVEL dB 60
PANEL DISPLAY . . . . . .in
INTEGRATION TIME . . . . . .as desired
MEASUREMENT MODE . . . . . SINGLE
OUTPUT DISPLAY . . . . . XY PLOT
DISPLAY RATE . . . . . .manual line

Table 3-13
CHART PAPERS FOR 1522 DC RECORDER

GR PART NUMBER	VERTICAL SCALE	HORIZONTAL SCALE
1522-9640*	Linear	Linear, 5 div/in.
1522-9647*	10 dB/in.	30 bands — not marked
1522-9646	12 dB/in.	30 bands — not marked
1522-9652	12 dB/in.	5-34 3.15 Hz-2.5 kHz
1522-9648	12 dB/in.	5-49 3.15 Hz-80 kHz
1522-9645	12 dB/in.	11-40 12.59 Hz-10 kHz
1522-9644	12 dB/in.	14-43 25 Hz-20 kHz
1522-9658	5 dB/cm	30 bands — not marked
1522-9656	5 dB/cm	5-34 3.15 Hz-2.5 kHz
1522-9654	5 dB/cm	5-49 3.15 Hz-80 kHz
1522-9657	5 dB/cm	11-40 12.59 Hz-10 kHz
1522-9655	5 dB/cm	14-43 25 Hz-20 kHz

*Total ordinate range is 60 dB, except -9640, which is linear, 50 div, and -9647, which is 50 dB.

d. Press the HOLD TO RELEASE button on the 1522, and, while holding it in, turn the MANUAL CHART ADJUST wheel to bring the pen near the first line on the paper.

e. Press the START button on the 1926. Integration starts and the INTEGRATING light glows. Nixies should indicate 60.00 and the pen should move to near the full-scale line on the paper. Press the PAUSE button on the 1926. Adjust the VARIABLE SENSITIVITY control on the 1522-P1 to position the pen exactly on the full-scale line. Release the PAUSE button.

f. Press the MANUAL ADVANCE button. The bottom-scale calibration channel level (00.00 dB) will be displayed on the Nixies and the pen will move back to the first (zero) line on the paper. Press the PAUSE button. Adjust the ZERO ADJUST control on the 1522 to position the pen exactly on the line.

g. Repeat the procedures of steps e and f.

h. Release the PAUSE button and push the STOP button.

The 1522 is now calibrated for 60-dB full scale.

Recording

To make the recording, set the controls on the 1926 as follows:

LOWEST BAND NUMBER . . . lowest active band
HIGHEST BAND NUMBER . . .highest active band
INTEGRATION TIME . . . . . .as desired
MEASUREMENT MODE . . . . . .as desired
OUTPUT DISPLAY . . . . . REMOTE ADVANCE
Other controls as noted above for calibration.

Set the 1522 SCAN switch to FAST.

Press the START button on the 1926. The level of each band in the spectrum will be recorded on the paper.

If the MEASUREMENT MODE control is set to SINGLE-HOLD, the same spectrum will be recorded repeatedly. If this control is set to SINGLE, one integration and one recording will be performed; then operations will stop. If it is set to MULTIPLE, the basic operations of integration and recording will repeat automatically and, for each measurement, a new spectrum will be recorded on a new chart.

To superimpose a second recording on the same chart, when the first recording has been completed and during the automatic chart-advance period, change the chart-direction switch on the 1522 to REVERSE. Then reposition the paper at the start of the chart and return the chart-direction switch to STOP. The 1522 is then ready to superimpose the second spectrum on the first.

To halt the Recorder without loss of the remainder of the analysis, press the PAUSE button on the 1926. At this time, the DISPLAY RATE can be changed and the BAND LEVEL can be read from the 1926 display. To pause at each band, set the DISPLAY RATE switch to MANUAL ADVANCE and press the XY PLOT button. Press the PAUSE button again to release it and press the MANUAL ADVANCE button once, to advance one band.

Data Printer, MDS[1] Hi-Speed Digital Printers

The MDS[1] Printer records on paper tape a list of the band numbers and band levels supplied to it by the 1921 Analyzer. American Standard Band Numbers (S1.6) and levels in decibels with virtually any desired reference level are printed.

The Printer should be used when most accurate numerical data is desired. Much time can be saved by printing band levels directly rather than reading them from a plotted curve.

The Analyzer supplies band-number and band-level information in BCD 1-2-4-8 code serially by band, with standard TTL logic levels. Any data printer that has a capacity of seven columns or more and will accept the code and logic levels can be used with the Analyzer. When a rapid succession of measurements is to be made and printed, it is important that the printer be fast. This minimizes the time needed to output data and maximizes the time available for measurement.

The MDS Printers operate synchronously with the Analyzer in the REMOTE ADVANCE OUTPUT mode at the given speeds in Table 3-14. Thus, a thirty-band measurement is printed in less than 3 s.

The Printer can be supplied by GR complete with a suitable printing format and interconnecting cable in conjunction with a 1921 Analyzer, or as part of a larger system, or it can be purchased directly from Mohawk Data Sciences.

XY Plotter, Houston, Series 6400 Omnigraphic$_{tm}$ Recorders.

The Houston Instrument Series 6400 Omnigraphic$_{tm}$ Recorders are general-purpose XY recorders having the unique advantage of using paper movement for an X variable, rather than the conventional technique of moving a beam across a fixed sheet of paper. The use of fan-fold paper having a series of independent grids gives the user sequentially presented XY plots. Each graph can be detached to yield a plot identical to that obtained from a standard XY recorder; or it can be kept in the fan-fold

[1]Mohawk Data Sciences Corp., E. Fourth St., Bridgeport, Penn., 19405.

Table 3-14
SYNCHRONOUS OPERATION OF MDS PRINTERS WITH THE 1921

MDS PRINTER SERIES	LINES/S	APPROX. TIME TO PRINT 30 BANDS
800	12	2½ s
1200	20	1½ s
1600	40	¾ s

sequence and referred to as a page in a book. Chart advance can be controlled manually, automatically, or remotely. The paper movement can also be reversed so that repetitive trace plots can be run.

Conventional XY plotters can also be used with the 1921 Analyzer, but they are not recommended because they require paper loading and, therefore, reduce the potential speed advantages of the analyzer system. The Houston 6420-024 and 6450-024 operate completely automatically with the 1921, which supplies appropriate pen-up, pen-down, and chart-advance signals to the recorder, as well as a 1-V, peak, X-axis sweep signal.

When the Houston recorders are used with a 1921, a DISPLAY RATE of 2 BANDS PER SECOND should be selected and the OUTPUT DISPLAY should be set to XY PLOT. These recorders are recommended when a standard XY format is desired. The 6420-024 uses 8 1/2 x 11 in. sheets and the 6450-024 uses 11 x 17 in. sheets.

The Houston recorders can be supplied by GR complete with suitable interconnecting cable and chart paper in conjunction with the 1921 Analyzer, or as part of a larger analyzer system, or they can be purchased directly from Houston Instrument.

IBM Key Punch, Type 1791 Card Punch Coupler.

The Type 1791 Card-Punch Coupler is used to transfer data from digital measurement devices to an IBM 526 Printing Summary Punch, which then records the data automatically on punched cards. The Coupler converts the parallel BCD information from the measurement device to serial 10-line contact closures required by the punch. In addition to the punch, parallel data-processing instruments (data printers, etc.) can be connected to the Coupler.

A coupler for use with the Analyzer can be supplied by GR.

Theory—Section 4

4.1 GENERAL 4-1
4.2 THE 1921 REAL-TIME ANALYZER 4-2
4.3 DETECTOR 4-4

NOTE

Over-all system theory is presented in this section. Detailed circuit theory for component equipments (1925/1926) is covered in their respective manuals.

4.1 GENERAL.

The essential difference between real-time and conventional swept- or stepped-sound-and-vibration analyzers is that the real-time analyzer accepts input data continually (as it occurs) and analyzes all of it. Information is taken into account all of the time, over the entire frequency range of the analyzer.

A conventional analyzer uses a single filter and detector. The filter is tuned and sometimes the detector or averaging circuits are also tuned. Or, a bank of fixed filters is switched to a common detector.

A serial, or conventional analyzer assumes that the input signal does not change as the single filter is tuned over the frequency range of interest. This may or may not be the case. When the signal is not stationary (i.e., when it varies with time), the segment or segments of interest can be tape recorded and played back repeatedly in such a manner that the entire segment is presented to the single filter channel at each center frequency. The process avoids the problems presented by a time-varying signal and permits an accurate spectrum analysis to be derived from a signal of short duration. All of the signal is analyzed by this method, but not as it occurs. Much time is required to prepare and play back the tape loop, and many other problems are associated with this technique.

In contrast, the real-time analyzer has, in effect, many filter and detector channels. All are fed with the same signal simultaneously and all spectral points are, therefore, derived from the same segment of signal. This method is extremely fast and the spectral information is available either directly after the time signal has been fed to the analyzer or soon thereafter.

It is worth noting that, by accepted definition, a real-time analyzer does not necessarily need to be fast. It is only necessary that it be capable of processing a signal continuously without missing any of the time record.

Another way to speed up a spectrum-analysis system, aside from parallel processing, is by handling and/or reducing the spectral information automatically, and this usually implies a digital-output format. When the spectral information is in digital form, a computer can be used to reduce the data, to find ratings, and to make comparisons.

There are a number of possible methods of implementing a real-time sound and vibration analyzer — an analyzer with, say, 1/3-octave bandwidth. A conventional analog approach could be used. A block diagram of such a system is shown in Figure 4-1. It consists of a set of 1/3-octave filters followed by a set of analog detectors. Active analog filters are now widely used and allow banks of filters to be pre-packaged in a small space at reasonable cost, even at low frequencies. The detector section is not this simple.

Because of the complex nature of signals that occur in sound and vibration work, random noise, impacts, multiple sine waves, etc., conventional range changing in the detector is not practical. A range-changing scheme works by making a trial measurement, then adjusting the range to give the final answer. This implies that some of the input signal is wasted in the trial measurement and, therefore, real-time operation is not possible without some measure of storing input data. Even with range changing, the detector is unable to handle "instantaneous" level changes exceeding the range of the basic detector.

The detector must have sufficiently wide dynamic range to cover the expected spectrum. If band levels are

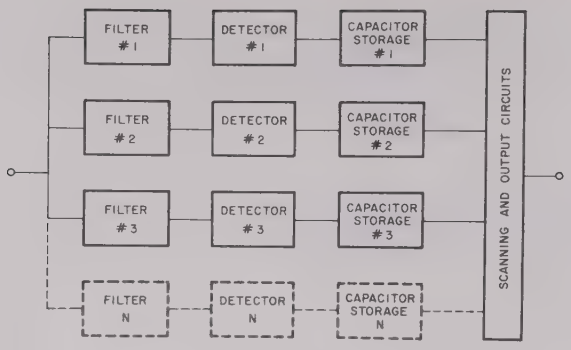


Figure 4-1. Block diagram of conventional analog system.

anticipated over a range of, say, 50 dB, the detector must have a dynamic range of 50 dB, and so on. Although it is a simple matter to design an analog filter or other linear circuit with a dynamic range sufficiently wide for use in an analyzer intended for real-time sound and vibration work, this is not the case for the required square-law detector. An RMS or mean-square measurement is most often desired, because it gives a measure of the energy in a signal. Peak and average detectors are not generally considered suitable.

An analog detector with "instantaneous" dynamic range greater than 35 or 40 dB is virtually impossible to make. A method of increasing the "average" dynamic range of an analog detector is employed in conventional level recorders and so-called linear-log converters. It amounts to continuous ranging. The input signal is detected and averaged and a fed-back signal derived from this output is used to compress the range of levels that the detector actually sees. This approach has the same shortcomings as conventional ranging techniques. The detector system cannot respond instantaneously.

Digital filtering and the Fourier transform have been known for some time and the science of digital-signal processing is now rapidly advancing. The Fourier transform is a natural spectrum analyzer, but, although it is easy to apply and understand for a simple periodic signal, unfortunately its use in analyzing complex or random signals is not yet fully understood and processors are just now available with sufficient speed to cover the audio range in real time. Though a practical, wide-dynamic-range, real-time, 1/3-octave, spectrum analyzer is within the realm of possibility, it would be a very expensive device. Digital filtering must be ruled out because present-day processors are still too slow for full-audio-range 1/3-octave processing in real time.

4.2 THE 1921 REAL-TIME ANALYZER.

4.2.1 General.

The approach used in the Type 1921 Real-Time Analyzer is to employ analog filtering and digital detection. This method takes full advantage of both analog and digital techniques. Using digital techniques, there are no limits on accuracy or dynamic range, even when the required transmission is nonlinear. There are some problems in converting a signal from analog to digital form, and digital processing would not be practical without low-cost digital integrated circuits.

A block diagram of the 1921 real-time analyzer is shown in Figure 4-2. The filters and associated circuitry are in the Type 1925 Multifilter; the detector circuitry is contained in the Type 1926 Multichannel RMS Detector. Both of these chassis are housed in a common cabinet.

The signal to be analyzed is connected to the input of the 1925 Multifilter. In standard versions there are 30 filter channels. All attenuator-filter channels are driven simultaneously by the signal to be analyzed. The gain in each filter channel is calibrated and adjustable in 1-dB steps. The 1925 Multifilter functions as an input spectrum shaper or equalizer.

Input spectrum shaping is used to:

1. Compensate for frequency-response errors in input transducers, a tape recorder, or other system component;

2. "Pre-whiten" the input signal, to increase the effective dynamic range. An effective dynamic range of 95 dB can be achieved in this manner.

The 1/3-octave filters used in the 1921 analyzer are standard six-pole design, meeting IEC Recommendation Publication 225-1966 and ASA Standard S1.11-1966, Class 3 (high attenuation). One-third-octave filters ranging in center frequency from 3.15 Hz to 80 kHz are used in the various models of the Type 1921 Real-Time Analyzer. Octave bandwidths and other special bandwidths ranging from 1/3 octave to 1/10 octave are available through our Custom-Products Operation.

The attenuation and filtering in the 1921 Analyzer are achieved in parallel circuits. The remainder of the analyzer

circuits are time shared on all channels. Operation is effectively parallel. Actually, the remaining circuits operate on samples taken from the filters. These samples are taken from all filter channels during the course of the measurement and processed in what can be thought of as a simple digital computer that sees to it that the samples do not get mixed up or lost. As many as 45,000 samples can be involved in a single measurement.

The multiplexer is really a very fast electronic commutator. It takes samples from the filter channel one at a time, and delivers these samples to the analog-to-digital converter. In the A/D converter, samples are converted to digital binary numbers and all further processing is done on these numbers.

Several major advantages derived from processing the signal digitally in the detector are presented in following paragraphs.

4.2.2 Dynamic Range.

Once the signal is converted to digital form, there is really no fundamental limitation on dynamic range, as there is in analog techniques. In the 1921 Analyzer, only the multiplexer and A/D converters strain analog capabilities, and these circuits have a dynamic range (measured from overload to noise level) of more than 80 dB. Once a sample is converted to a binary number, it is only necessary to carry enough significant digits for the dynamic range and accuracy required.

4.2.3 Accuracy.

It is impossible to make a simple, yet complete, accuracy statement for a device as complex as a real-time spectrum analyzer. However, a number of important observations can be made. The digital method used in the 1921 circumvents the accuracy limitations of analog schemes. Again, in digital, there are no fundamental accuracy limitations. The arithmetic can be performed to any desired resolution, and, of course, all signals are processed through the same channel so, channel-to-channel uniformity is not a consideration.

The largest errors occur in analog detectors when they are presented with unusual wave forms. For example, a pulse or burst with a short duty ratio can result in errors of many decibels.

Taking into account a number of minor errors due to noise, component tolerances, and round-offs in the multiplexer and A/D converter, it can be stated that the detector's basic accuracy over nearly its entire amplitude and frequency range is ±0.5 dB.

4.2.4 True Integration Characteristics.

Many samples taken from each filter channel are squared and averaged to determine the band levels. When the START button is pushed, the detector commences to take samples from the filter channels until the pre-selected integration time has elapsed. Samples are taken only during this period, and all samples are weighted equally in the result. The integration is thus linear (nonsaturating) and the time period during which the measurement is made is accurately known. It is easy to vary the average rate at which samples are taken to produce any desired integration period. The 1921 has a choice of nine integration periods, ranging from 1/8 s to 32 s.

In comparison, the analog system has several disadvantages and no advantages. Long-time analog integrators, in the quantity needed for a real-time detector are impractical. To change integration time requires that a component in each detector channel be switched. This, too, is

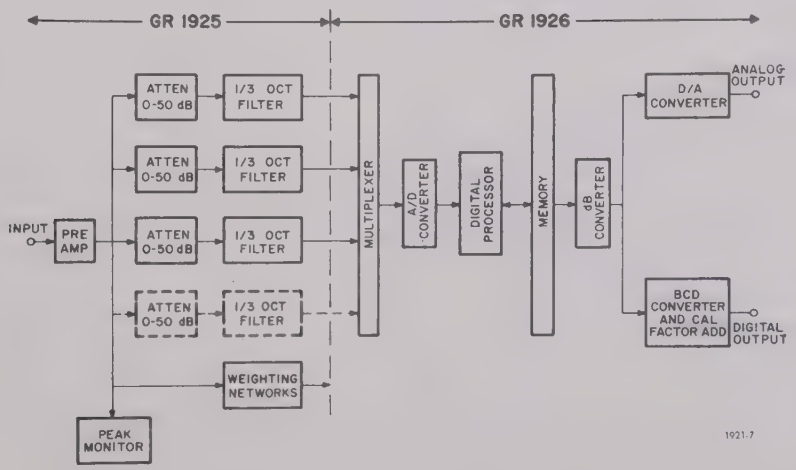


Figure 4-2. Block diagram of the 1921 Real-Time Analyzer.

an expensive, electronically cumbersome proposition. In an analog design, one must settle for a very few integration or averaging periods. Also, the only practical averaging method is simple RC averaging. When presented with a signal, the output from this type of averaging circuit tends toward a finite saturation level. Events that occur early in the time signal are "forgotton", or leak off, and it is impossible to know exactly to what degree each event in the time signal has affected the answer. A detector of this kind is not very useful for transient signals. Also, several time constants are needed to bring the detector to saturation, the level for which it is calibrated, and this means that a longer time signal is needed for a given statistical accuracy if the signal is random.

At the end of an integration period, the analyzer is ready to "output" the spectral information. Band levels are read out in both analog and digital form, simultaneously. The stored band levels are converted to decibels during the output cycle and a calibration factor is added to the digital signal. The calibration factor is selected by a front-panel control and allows the user to read out decibels for virtually any reference level. A 0.1-V "full-scale" input signal to the analyzer can be made to correspond to any integer number of decibels in the range from 60 to 159. A D/A converter is used to generate the output analog signal.

4.3 DETECTOR.

4.3.1 General.

The 1926 Multichannel RMS Detector computes simultaneously the true rms levels for each separate input channel. Up to 1024 samples are taken of each input. Each sample is converted to a digital word and is squared. The squared values of each sample are accumulated in a memory register where spaces are provided separately for each input channel. At the end of an integration period, the memory register holds the sum-of-squares value, which is later converted to decibels for output presentation of the corresponding true rms value.

The above describes the operations that take place during a single integration or measurement period, which is adjustable in nine octave steps ranging from 1/8 to 32 s. For integration periods of 1 s and longer, 1024 samples are taken. For shorter integration periods the number of samples is proportionately reduced, with a minimum of 128 samples being used for a 1/8-second integration.

The frequency of sampling is different for each integration period (1 s and longer) and is lower than most input signals within its operating range of 2 Hz to 100 kHz. Uniformly spaced samples would, therefore, be coherent with many values of input frequency. To avoid coherence with input signals, the time space between samples is linearly modulated. Because there is no attempt to reconstruct signals, however, this is of no consequence. Rms measurements can be accurately made at a low sampling rate, in the absence of coherence effects.

At the end of an integration period, the sum-of-squares value is converted to decibels for output presentation. Levels are computed within 15 μs per channel, and all channel levels can be presented in less than 1 ms.

Output data is simultaneously presented in digital (with BCD format) and analog forms, plus a front-panel Nixie-tube readout. Control signals and format are designed to interface the output with a digital computer, printer, oscilloscope, or X-Y plotter.

A scale-factor adder adjusts the output-level readings when the 1926 is used as a system component. Normally, a 1-V, rms, input produces an output-level reading of 60 dB. This reading is adjustable in 1-dB steps to a maximum of 159 dB. This adjustment has no effect on the analog output levels.

Band numbers are displayed with each output level, and correspond to the USA Standard Band Numbers for 1/3-octave or active filters (S1.6- 1967). The number of channels to be displayed is controlled by the LOWEST BAND NUMBER and HIGHEST BAND NUMBER control settings.

Two extra internal channels are included, to calibrate 0 and full scale on the 1926. They are measured during each integration period and can, therefore, be used to continuously monitor calibration, if so desired. The calibration channels are also intended to be used to set up analog output equipment, such as an X-Y recorder or oscilloscope.

4.3.2 Principles of RMS Measurement.

A voltage wave, v(t), has a mean value $\overline{v}(t)$

$$\overline{v}(t) = \frac{1}{T}\int_0^T vt\,dt \qquad (1)$$

The mean square value of v(t), taken about its mean, is called the variance, σ^2

$$\sigma^2 = \frac{1}{T}\int_0^T [v(t) - \overline{v}(t)]^2\,dt \qquad (2)$$

The square root of σ^2 is called the root-mean-square, or rms, value of v(t). (Note that σ^2 excludes dc).

If we assume that $\overline{v}(t) = 0$, equation (2) reduces to

$$\sigma^2 = \frac{1}{T}\int_0^T [v(t)]^2\,dt \qquad (3)$$

and the rms value becomes

$$\sigma = \sqrt{\frac{1}{T}\int_0^T [v(t)]^2\,dt} \qquad (4)$$

When the data are discrete, the voltage v(t) is known only at discrete instants of time, t. The integral of equation (4) reduces to a summation and we have

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{N} [v(t_i)]^2} \qquad (5)$$

where N = number of samples.

The rms value, therefore, is equal to the square root of the sum of the squares of v (t_i) divided by the number of samples.

The 1926 Detector measures the values $v(t_i)$ with a 1-mV reference level. The rms level in decibels above 1 mV is, therefore,

$$\begin{aligned} \text{rms} &= 20 \log_{10}\left(\frac{\sigma}{\sigma_0}\right) \text{dB} \\ &= 10 \log_{10}\left(\frac{\sigma}{\sigma_0}\right)^2 \text{dB} \end{aligned} \qquad (6)$$

Combining equations (5) and (6),

$$\text{rms} = 10 \log_{10} \left\{ \frac{1}{N} \sum_{i=1}^{N} \left[\frac{v(t_i)}{v_0}\right]^2 \right\} \text{dB} \qquad (7)$$

(σ_0 and v_0 are reference levels.)

Equation (7) is computed by the 1926, and avoids the square-root operation by using 10 $\log_{10}$. As a further simplification, N is always a binary number, so that division by N is simply a binary point shift.

4.3.3 Decibel Conversion.

All output measurements of the 1926 are in decibel units. During the output phase of operation, the digital memory has the mean-square measurement values (called the variance, σ^2) in storage, which are converted to rms in dB, using the operations described by equation (6).

$$\text{rms} = 10 \log_{10}\left(\frac{\sigma}{\sigma_0}\right)^2 \text{dB}$$

The memory format is floating-point binary, so that σ^2 is a number stored in two parts, a mantissa, m, and a binary exponent, E;

$$\sigma^2 = m \cdot 2^E \qquad (8)$$

Substituting (8) into (6),

$$\begin{aligned} \text{rms} &= 10 \log_{10} m + 10E \log_{10} 2 \text{ dB} - 10 \log_{10} \sigma_0 \\ &= 10 \log_{10} m + 3.01E \text{ dB} - 10 \log_{10} \sigma_0 \end{aligned} \qquad (9)$$

The ($10 \log_{10} m$) term of equation (9) is a component that lies between 0 and 3 dB, because m is a number that lies between 1.0 and 2.0. The second half of equation (9) is a component that lies between 0 and 60.2 dB, because E is an integer number that lies between 0 and 20. The third term is a constant that accounts for the reference level.

The output data is quantized in 0.25-dB steps, making a total of 240 possible output steps for the dynamic range of 60 dB. Between 0 and 3 dB there are 12 steps (the possible outcomes of the output computation using the mantissa, m). For outputs between 3 and 6 dB, the exponent E equals 1 and again 12 steps are needed. This process repeats up to a maximum of 60 dB, where E=20 (actually for 60.2 dB). Using 12 steps for the mantissa and 20 for the exponent, therefore, a total of 240 steps are possible (12 times 20), using a very simple computational algorithm.

The (3.01E) term of equation (9) is not a whole number, but the above discussion assumes it to be. In the actual computation this fractional difference is ***not*** ignored, however.

Computation of the first half of equation (9) is achieved with a fixed conversion matrix. It accepts a 5-bit input (32 possible inputs), and has 13 possible outputs (12 steps plus 0).

Service and Maintenance—Section 5

5.1 GR FIELD SERVICE 5-1
5.2 MINIMUM-PERFORMANCE STANDARDS 5-1
5.3 TROUBLE ANALYSIS 5-2

5.1 GR FIELD SERVICE.

The two-year warranty stated attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please contact our Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to mention the type, ID, and serial numbers of the instrument.

Before returning an instrument to General Radio for service, please contact our Service Department, or nearest District Office, requesting a "Returned Material" number. Use of this number will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

Table 5-1
TEST EQUIPMENT

INSTRUMENT	REQUIREMENTS	RECOMMENDED MODEL
Oscillator	1-V output into 600 Ω. Frequency range to include all bands of the 1921.	GR 1310

5.2 MININUM-PERFORMANCE STANDARDS.

The following tests should be performed for incoming inspection, periodic operational checking, or calibration verification of the 1921 Real-Time Analyzer. The equipment required is listed in Table 5-1.

To check that each 1/3-octave filter, and the corresponding detector channel, are working properly, use the following procedure.

a. Set the controls on the 1926 as follows:
LOWEST BAND NUMBER — 30
HIGHEST BAND NUMBER — 30
PANEL DISPLAY — in
INTEGRATION TIME — SECONDS — 1/8
MEASUREMENT MODE — MULTIPLE
OUTPUT DISPLAY — PRINTER
DISPLAY RATE — BANDS PER SECOND — 64
Line-voltage slide switch to the line voltage. Circuit ground slide switch to DIRECT.

b. Connect the oscillator to the INPUT of the 1925. Patch cord P/N 0776-9701 (shielded double plug to BNC plug) should be used with the 1310 Oscillator. Connect the line power to the oscillator and to the 1921 and turn on the POWER switches.

c. Set the oscillator frequency to 1 kHz and adjust its level to give a reading of 50.00 dB on the BAND LEVEL dB indicators.

d. Change the LOWEST BAND NUMBER setting to the "60" (full-scale) calibration channel (two channels below the lowest active band; refer to paragraph 3.2.2). Set the HIGHEST BAND NUMBER control to the highest active band to be checked.

e. Change the DISPLAY RATE switch setting to MANUAL and push the START button. The BAND LEVEL dB indication should be 60.00 (for the full-scale calibration channel).

f. Push the MANUAL ADVANCE button once only. The indication should be 00.00 (for the bottom-scale calibration channel).

g. Set the frequency of the oscillator to the center frequency of the lowest active band. Push the MANUAL ADVANCE button. The BAND LEVEL dB indication should be approximately 50.00.

h. Repeat the procedure of step g at the center frequency of each active band over the entire range of the 1921. In each case, the indication should be approximately 50.00 dB. If any incorrect channels are discovered, follow the trouble-analysis procedure of paragraph 5.3. The minimum-performance and trouble-analysis procedures for the 1925 Multifilter and the 1926 Multichannel RMS Detector are given in the Service and Maintenance Sections of the individual Instruction Manuals, which are included in this book.

5.3 TROUBLE ANALYSIS.

Trouble analysis of the 1921 should be carried out in the following manner:

a. Perform the complete system check given in paragraph 5.2. Note all symptoms that indicate trouble.

b. Remove the interconnecting cable (P/N 1921-0200) between the 1925 and the 1926. Repeat the procedure of paragraph 5.2 on the faulty channel only, omitting the 1925 Multifilter. Insert the oscillator input at the proper terminal of the AJ5 CHANNEL INPUTS connector on the 1926. If the trouble encountered in step a, above, is still present, the fault is with the 1926. If the error has disappeared, the trouble is with the 1925. After determining which instrument is at fault, refer to the detailed trouble-analysis procedures for the 1925 Multifilter or for the 1926 RMS Multichannel Detector, which are given in the Instruction Manuals for these instruments and are included in this book.